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Imperial Irrigation District

Metropolitan Water District of Southern California

Water Conservation Agreement

PROJECT 9
12-HOUR DELIVERY PROGRAM
VERIFICATION SUMMARY REPORT

Conservation Verification Consultants

June 30, 1999

Conservation Verification Consultants

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To: Water Conservation Measurement Committee Members

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Dear Sirs,

Transmitted herewith is the FINAL DRAFT of the Conservation Verification Consultants' Verification Summary Report (VSR) for Project 9: 12-Hour Delivery Program. It is a new updated VSR that presents the CVC's final procedures for developing Conservation Projections beginning with year 2000. It also includes the interim verification reports for determining the Net On-Farm Savings (final version dated September 1996) with its Addendum to preserve the development history of the Conservation Projections for the 12-Hour Delivery Program.

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INTRODUCTION

Project 9 -- 12-Hour Delivery Program was included as Project 9 in the December 1988 Imperial Irrigation District/ Metropolitan Water District of Southern California (IID/MWD) Water Conservation Agreement. The first 12-Hour Delivery (12-HD) orders were taken and filled in the Fall of 1989 and the annual number of 12-HDs is now over 20,000 in the service area outside of the three Lateral Interceptor Projects sponsored by the Conservation Agreement.

Prior to the implementation of the 12-HD Program, for the most part, farmers were only given the opportunity to have their regular water orders started, shutoff, increased, or reduced at the beginning (or end) of once each 24-hour period. These ordinary water orders are now termed 24-Hour Deliveries (24-HDs). The IID zanjeros (ditch-riders) begin their daily operational runs at about 6:00 AM to change farm water deliveries in response to farmer's water orders made by noon of the previous day. Each zanjero is responsible for managing a specific set of laterals and the respective farm delivery gates they serve, which is called a zanjero run. It takes them 3 to 4 hours to complete their runs. The zanjeros progress through their runs in a systematic manner, thus the first farm delivery gate on each zanjero run is attended to at about 6:00 AM and the last between 9:00 and 10:00 AM, but each 24-HD order receives water for approximately 24-hours. Furthermore, each farm gate has a specific time (plus or minus about 15 minutes). in the morning when a zanjero will be there to take care of the respective farmer's 24-HD water order.

The essence of the 12-HD Program is that it provided farmers with the opportunity to have their water order started both in the morning (AM) and evening (PM) instead of only in the AM; but to qualify for this twice-a-day service the flow-rate (or size) was limited to 7-cfs (cubic feet per second) under the original terms of the 12-HD Program. This was changed in the fall of 1996 because of the difficulty of servicing the large number of 12-HDs, and now the orders are capped at 5-cfs in the spring and fall, but the cap is still 7-cfs in the winter and summer, when there is a lesser demand for 12-HDs. Originally the use of 12-HDs was fairly inflexible and farmers were held to keeping their 12-HD orders for a full 12 hours, but now farmers are allowed greater flexibility and may have their 12-HD shutoff at almost any time, providing sufficient advance notice is given. Another feature of 12-HDs is that the farmer are only charged for the water that is actually delivered, whereas, for 24-HDs they must pay for the quantity of water ordered, regardless of when they have it shutoff.

This Conservation Verification Summary (VSR) Report is organized into the six sub-sections outlined below. It supercedes an earlier VSR that focused on the Conservation Element (dated September 1996 and an Addendum to it (dated September 1998). The early VSR and its Addendum are included herein in their initial forms and page numbering systems as Appendix A and B.

Following are the names and a brief description of the purpose and content of each sib-sections.

- **Background:** The background section includes a general descriptions of verification principles for the 12-HD and the history and development of the verification strategy.

- **Verification of Conservation Element:** This is the heart of this VSR. The first part of it contains the strategy for the development of the basic data used it the formulation of the sets of mathematical equations that were developed to quantify the net on-farm water conserved as a result of the 12-HD program. The conserved water is expressed in terms of the reduction in farm deliveries. This set of basic data is referred as the 1:10 Database. The second part of the section covers the evolution of the development of the mathematical formulations, which are called Inference Models, leading up the final model. The third part of the section provides a description of how to use the data from the 1:10 Database along with data queries from IID's detailed canal and farm delivery data stored in the Water Information System. It ends with a step-by-step example calculation to demonstrate the use of the final Inference Model using 1998 Water Year data to obtain the Conservation Element of the 12-HD Program.

- **Verification of Consequential Effect Element:** As a consequence of providing 12-HDs extra lateral (and main canal) flow changes are required when the 12-HDs. are shutoff (in addition the regular flow changes necessary for providing the AM service for the mixture of regular 24-HDs and 12-HDs). These extra flow changes and the associated canal manipulations induce additional lateral spillage over and above the ordinary operational spillage. To account for this, a small volume of spillage is charged as a consequential effect of each 12-HD on non-intercepted laterals. The details for estimating the per 12-HD effect are covered in the CVC's Final Canal Spillage Report. However, the development of this Consequential Effect Element is presented in this section using 1998 Water Year Data.

- **Allocation of 12-HD Savings Between Projects 9 And 15:** A portion of the water conservation savings resulting from the added flexibility afforded by 12-HDs is allocated to the Project 15 - System Automation. This is because having the additional automation facilities to better control the flows in the main delivery system is critical to IID's ability to accommodate the large number of 12-HDs without causing excessive delivery fluctuations and spillage. The allocation of the Conservation and Consequential Effect Elements between Projects 9 and 15 is based on the ratio of the sum of their respective annual Capital plus O and M costs. Details for estimating this ratio based on the situation at the end of 1998 are presented in this section.

- **Annual Conservation Projections:** This section is presented to demonstrate the process (using 1998 Water Year data) required for making the calculations for the CVC's Conservation Projections. The results of the estimated Conservation and Consequential Effect Element are presented in the same tabular format as is used in the CVC's annual Conservation Projection Reports with the tabular summaries.

- **Independent Validation Analysis:** This section contains the results of the analysis of IID water delivery data that is designed to provide and alternate estimate of the net conservation savings of the 12-HD Program. The analyses presented in the section are entirely different than the (above) verification analysis. Thus it provides and independent mean for validation it.

Careful attention has been given to presenting precise definitions for many of the special and important terms used herein. Glossaries of these terms are presented at the beginning of the Background and Verification of Conservation Elements Sections. These are consistently set in italics throughout to add preciseness and clarity.

BACKGROUND

Introduction

There has been considerable change in the amount of delivery flexibility IID offers since the 12-HD Program was initiated and the way farmers utilize it. However, the central feature of the program has remained essentially the same. The program provides farmers with two daily turn times approximately 12-hours apart, morning and evening, and the service of having deliveries automatically terminated after 12-hours or at any other time if they give sufficient notice. Originally farmers were allowed to place 12-HD orders of any size up to 7 cfs during all seasons of the year.

To avoid inducing excess lateral or main system spillage, IID water managers must make special provisions for handling the water that is no longer being delivered at the farm gate whenever a 12-HD is terminated. The flow that is no longer needed is in effect "returned" to IID water managers who must find a use for it somewhere else. Project 15 -- System Automation enhances their ability to handle the returned flows of water. However, as the usage of 12-HDs continued to grow especially in the spring and fall, there came a time when the IID/MWD Conservation Program Managers deemed it necessary to limit the growth of the returned flows. To accomplish this, 12-HD orders were restricted to a maximum flow rate of 5 cfs beginning in the fall of the 1996 Water Year. Thus there is a 5-cfs Cap on orders in the spring and fall and a 7-cfs Cap in the winter and summer when there fewer 12-HD orders.

The body of this section begins with a general description of the water savings concepts related to the 12-HD Program. Then the history and development of the verification strategy is presented.

12-HD Program Description and Verification Concept

As with all of the conservation projects there is at least one Conservation Element, which result in reductions in water uses or losses due to the effects of the conservation project, and potential *Consequential Effect Elements*, which are increases in water uses or losses due to the effects of the conservation project.

Conservation Element. The only water conservation element is the *Reduction in Farm Deliveries* resulting from providing more flexible delivery service to farmers. The reduction is the difference between the annual volume of water that would have been delivered to farms if 12-HDs had not been available and the amount that is delivered.. The reduction in farm deliveries results from providing greater flexibility in the duration of irrigation deliveries. Also, it results from the fact that IID water operators have greater latitude in managing water that is "returned" when 12-HDs are shutoff, because of Project - 15 System Automation.

Consequential Effect Element. The only consequential effect element of the 12-HD Program is the *Induced Lateral Spillage* resulting from starting or shutting-off 12-HDs outside of the *Normal Operation Window*, which is when the regular 24-Hour Deliveries that make up the bulk of the water deliveries are started or shutoff.

Net Conservation Savings. The net conservation savings is the difference between the Conservation and Consequential Effect Elements, so that:

Net Conservation Savings = Conservation Element - Consequential Effect Element

Glossary of Terms and Definitions. A number of terms for which the definitions should be concise and consistent are used in describing and developing the 12-HD Project Conservation Verification Strategies and Projections. Following are the important terms used in developing the Conservation and Consequential Effects Elements.

Water Year. A 12-month period beginning October 1 and ending September 30, inclusive; xxxx denotes the calendar year containing the January 1 to September 30 period.

Calendar Year. A 12-month period beginning January 1 and ending December 31, inclusive.

(Water) Delivery Detail Data. The digital IID records of farm water deliveries from November 1, 1996 to date.

12-HD. A farm water delivery event ordered for a nominal duration of 12 hours as identified in the IID delivery detail records.

(v_c), AF. Net on-farm volume of water conserved by a 12-HD.

Sub-set. A sub-set of the 12-HD events defined by water application method, order size and season.

Normal Operation Window. The time period unique to each farm delivery gate during which water delivery is normally started and stopped.

Reduced Farm Delivery (12-HD). The difference between the annual volume of water that would have been delivered to farms if the conservation project had not been constructed and the volume that was actually delivered with the project. *(12-HD)* denotes that the reduced delivery is the result of the 12-Hour Delivery Program. It is the only conservation element of Project 9. The *(12-HD)* part of the definition is included because other projects have additional types of Reduced Farm Deliveries; however, for convenience it will usually be dropped herein.

Shutoff-loss per 12-HD. Increment of lateral spillage resulting from the termination of each 12-HD on non-intercepted laterals.

Induced Lateral Spillage (12-HD). The annual volume of additional spillage from non-intercepted laterals above lateral base spillage that results from providing 12-HDs under the Conservation Program. It is a consequential effect of Projects 9 and 15.

Verification Laterals. The representative set of laterals for which there are continuing long-term spillage records used to compute base lateral spillage.

Base Spillage. The computed annual volume of lateral or main canal spillage that occurred or would have occurred during a given time period less any spillage that did or would have resulted from providing identified 12-HDs and flexible 24-HDs.

Development of Verification Strategy for Estimating *Reduced Farm Deliveries (12-HD)*

Three different processes including the current one have been employed to estimate the net on-farm or direct conservation savings associated with Project 9. These processes all feature an event-based delivery differential strategy (or approach) to estimate the gross and net on-farm conservation savings realized from each 12-HD:

$$v_c = v_{24} - v_{12}$$

$$(v_c) = v - v_{EU}$$

where:

v_c	=	gross volume of water conserved on-farm for a given 12-HD event, AF
v_{24}	=	estimated volume of water that would have been delivered for the event without the 12-HD Program (the without-project delivery), AF
v_{12}	=	volume of water actually delivered for the event with the 12-HD Program, AF
(v_c)	=	net volume of water conserved on-farm for a given 12-HD event, AF
v_{EU}	=	portion of gross volume of water conserved on-farm that is effectively used elsewhere for a given 12-HD event, AF

This general strategy acknowledges that estimating the volume that would have been delivered, v_{24}, is in effect an informed judgement of what each farmer would have done if only 24-Hour Deliveries (24-HDs) were available.

The CVC were asked to critique the first two 12-HD verification processes and the associated activities in early 1993. The initial process relied on the judgments of the Water Clerks in each of the six IID Divisions to specify the expected conservation savings, v_c, for each 12-HD. The second process involved selecting 12 cooperating growers, two from each of the six division at that time, and having the Assistant Division Superintendents query them to estimate the associated v_c for each of their 12-HDs in that Division. (It was not clear nor actually specified whether the expected conservation savings estimates being generated were net or gross, total or on-farm, at any rate the values being generated were used as if they were net on-farm savings values.)

When the CVC was asked to critique the 12-HD verification processes, the program and its verification had been in effect for about 3 years. Therefore, rather than proceed with development of an independent verification plan, the CVC choose to conduct a critique of ongoing verification activities. As a result of this critique the CVC suggested that a different data collection process be employed for estimating the conservation savings associated with each 12-HD event and a new mathematical analysis procedure (Inference Model) be developed.

The 1-in-10 Grower Database[1]. In view of the CVC's concerns with using the data collected from the 12-Cooperating Growers to make the (v_c) estimates a new database and estimating procedure was recommended and initiated during the 1994 Water Year. Instead of concentrating on a few selected growers who were large users of 12-HDs, a random query was made of all growers who placed 12-HD orders. To achieve this, each Division was asked to have its Water Clerks count the 12-HD orders in sequence as they arrived and complete a special Grower Questionnaire for **every 10th 12-HD order** (see Form 1 in Appendix A). This required querying the appropriate grower or irrigation foreman.

The above procedure produced a random sample of 12-HD users and uses. Besides asking, "If 12-HDs were not available, what would you have ordered for 24-hours?" they were also queried about what would have been done with any excess water and why they were using 12-HDs. In addition to these special Grower Questionnaires, a Zanjero Information sheet to be filled out for **every 12-HD order** was also developed (see Form 2 in Appendix A).

By comparing the 1:10 Database with the District-wide counts it is clear that the random sampling program was successful. The 1:10 Grower Database is proportionally distributed across methods, seasons, Divisions, and crops (see percentages at bottom of Table 2 in Appendix A).

Early Inference Model Development. The design of the development of the 1:10 Database envisioned using the data in a spread-sheet type of analytical program, which will be referred to herein as an Inference Model. The early strategy for use of the data was to group the data (from the 1:10 Database) in *Sub-sets* of 12-HDs that had similar characteristics, such as method of irrigation or order size, but as a group had statistically different average (v_c) values. At the time the CVC anticipated that the irrigation methods of drip, flat, row, and sprinkle would play a major role in the grouping process.

Procedure for Estimating Average Savings/Event for Sub-sets of 12-HD Events. The procedures used for estimating the water conservation savings associated with 12-HDs were developed by analyzing the data gathered through the 1:10 Grower responses and the Zanjero Information sheets. The analysis was tempered by the information gained from interviews with 20 growers who utilized 12-HDs. The original analysis was then independently revisited and an additional 7 growers were interviewed to focus on areas in the original analysis and interviews that needed further clarification and possible modification.

Two basic assumptions implied in the procedure used to estimate the net on-farm conservation savings for each 12-HD event, (v_c), are: 1) only 12-HDs for agricultural irrigation are considered; and 2) each 12-HD would have had (or replaces) a corresponding 24-hour delivery, 24-HD. The procedure used to estimate $(v_c)_m$ values (for *Sub-sets "m"* of similar events) from the information contained in the 1:10 Database involved the following six steps (which are developed in detail in Appendix A):

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1 For details on the 1-in-10 Database see the CVC report included in Appendix - A *Summary of Initial Verification Procedure for Estimating Net On-farm Savings Resulting from 12-Hour Deliveries to Obtain Reduced Farm Deliveries(12-HD) for Projects 9 and 15*. Appendix A is a condensed version of the CVC report *Initial Verification Procedure for Estimating Net On-farm Savings Resulting from 12-Hour Deliveries to Obtain Reduced Farm Deliveries(12-HD) for Projects 9 and 15*. The summary report lays out the strategies used in the full report but leaves out much of the detail. The Main Report is the Annex referred to therein.

1. Classifying the 24-HD responses;
2. Applying a set of screening rules;
3. Adding a small amount of "buffer" water to 24-HD responses that are "Half" of the 12-hour order;
4. Estimating the probable effectively used portion, v_{EU}, of the excess water that would have been delivered to fill the "corresponding 24-HD" that the 12-HD was assumed to have replaced;
5. Computing the net on-farm water savings for each individual 12-HD event, $(v_c) = (v_{24} - v_{12} - v_{EU})$; and
6. Developing weighted averages for the individual 12-HD events for *Sub-sets* of like 12-HD events by summing the individual (v_c) values for each 12-HD event and dividing by the number of like events.

The initial procedures developed in Appendix A for establishing $(v_c)_m$ values also included the development of an Inference Model with six *Sub-sets* that utilized their $(v_c)_m$ values for estimating the *Reduced Farm Delivery (12-HD)*. This model is no longer valid because of 12-HD Program changes that have taken place, but (except for the effect of a minor revision in the effective utilization percentages) the same (v_c) values developed for the individual 12-HDs in the 1:10 Database are still being used.

Modification of Procedures for Estimating Conservation Savings. At the time the CVC report presented as Appendix A was finalized in September 1996 it was titled *Project 9 -- 12-Hour Delivery Summary Report -- Part I: Net -On farm Conservation Savings*. Since completing this Initial VSR for what is now termed Reduced *Farm Deliveries (12-HD)* a number of changes, as mentioned above, have been made and/or have taken place in the 12-HD Program.

To address these changes an Addendum to the initial VSR *Project 9 12-Hour Delivery Report, Part I: Net On-Farm Conservation Savings (Dated September 1996)* has been developed and is included herein. The first DRAFT of the Addendum was submitted to the Conservation Water Management Committee (CWMC) at the June 20, 1997 meeting and discussed. This first DRAFT contained sections covering a revision of the effective utilization (EU) percentages, and a revision of the inference model to handle the 5-cfs Cap imposed on the 12-HD orders during the spring and fall beginning in the 1996 *Water Year*. A second DRAFT of the Addendum containing a preliminary method for handling the growth of 12-HD usage and accounting for 12-HDs to serve Projects 14 and 18 was submitted at the January 28 1998 WCMC meeting and discussed.

The third and FINAL DRAFT of the Addendum, which is included as Appendix B herein, was submitted and discussed at the September 8, 1998 WCMC meeting. It contains updated and edited sections covering the revisions presented in the two earlier drafts plus the CVC's latest strategy for handling the growth in the usage of 12-HDs, an updated validation analysis, and an example computation for utilizing the a new inference model for determining the *Reduced Farm Delivery (12-HD)*. Only minor modifications have been made in the inference model for estimating the *Reduced Farm Delivery* since the completion of the Addendum.

Development of Verification Strategy for Estimating *Induced Lateral Spillage (12-HD)*

Management of the returned flows when 12-HDs are terminated results in additional lateral spillage compared to the normal operational spillage associated with the 24-HDs they replace. This additional spillage is captured and conserved where laterals are intercepted and the potential spills are immediately available for use down steam or stored for future use. However, for non-intercepted laterals part of the net on-farm water conservation saving, (v_c), associated with each 12-HD is offset by its *Shutoff-loss*. This is because the process of reducing the inflow of water to the laterals in a timely manner to accommodate the shut-off of each daytime 12-HD potentially increases the lateral's operational spillage.

Basic Need for Canal Spillage Study. The effects of 12-HDs on lateral spillage is the only Consequential Effect Element of the 12-HD Program and it must be accounted for to determine the Net Conservation Savings. This is necessary where lateral spillage is discharged into IID drains, but not where laterals are intercepted. However, because 12-HD use is widespread and only a few laterals have verification quality spillage records, it is no possible to directly compute the 12-HD-induced spillage volume for all non-intercepted laterals. Instead it is necessary to estimate 12-HD-induced spillage from the monitored laterals.

History of Studies and Estimates. In making the Conservation Projections for the 1995 through 1999 Calendar Years the CVC has used various techniques for estimating the *Induced Lateral Spillage* associated with the 12-Hour Delivery (12-HD). The CVC's final verification strategy for estimating the *Induced Lateral Spillage* was used for making the 1999 Conservation Projection and it is presented in the Final Canal Spillage Report referred to below. The interim techniques utilized for making the 1997 and 1998 Conservation Projections are included as interim reports in Appendixes C and D in the final Canal Spillage report.

Final Canal Spillage Report. The canal spillage analysis and studies are contained in the CVC report *Canal Spillage Analysis in Support of Conservation Savings Verification for Projects 3, 8, 9, 15, and 17*, dated July 1999. The CVC elected to develop this as a stand alone report because understanding and quantifying lateral spillage is an important aspect of conservation verification for five projects in the IID/MWD Water Conservation Program: Projects 3, 8, and 17, the lateral interceptor projects, and Project 15, System Automation in addition to the 12-HD Program. Thus it was most efficient to address canal spillage as a general issue because these projects either target canal spillage for conservation or cause spillage to increase as a consequence of project operation as is the case for the 12-HD Program. The report contains a description of the strategies used in developing the study and essential outputs resulting from it. Therefore, it was not necessary nor would it be efficient to include the details of that work herein.

Final Strategy for Estimating Induced Lateral Spillage. The final strategy selected for estimating the *Induced Lateral Spillage* (on non-intercepted laterals) resulting from terminating 12-HDs outside of the *Normal Operating Window* (when ordinary 24-HDs are terminated) is to assign an average increment of induced lateral spillage for each 12-HD. This spillage increment is called the *Shutoff-loss per 12-HD* (defined as the increment of lateral spillage resulting from the termination of each 12-HD on non-intercepted laterals). Then to estimate the Induced Lateral Spillage (12-HD) multiply the number of 12-HD events that occur on non-intercepted laterals by the *Shutoff-loss per 12-HD*.

Important Annexes (bound separately)

There are four important Annexes produced by the CVC for the this Project 9 VSR that are bound separately, these are:

1. The *Interim Detailed Verification Procedure for Estimating Net On-Farm Savings Resulting from 12-hour Deliveries to Obtain Reduced Farm Deliveries (12-HD) for Projects 9 and 15*. This report is in preparation and will contain the underlying data and details for analyzing the 1:10 Database for the Inference Models used in this report. It will be and updated version of the earlier unabridged

Draft Report titled *Project 9: 12- Hour Deliveries Verification Summary Report* dated October 1995.

2. The report developed for the 12-HD Verification Procedures Seminar titled, *Project 9 – 12-Hour Delivery Program – On-Farm Water Savings Verification Procedures Seminar*, Dated June 1996.
3. A report on the Special Meeting of the Water Conservation Advisory Board Presented by the Conservation Verification Consultants on June 19, 1997, titled, *Verification of the 12-Hour Run Program*, dated June 1997.
4. The Final Canal Spillage Report, *Canal Spillage Analysis in Support of Conservation Savings Verification for Projects 3, 8, 9, 15, and 17*, dated July 1999.

Coupled with this VSR these reports provide a window into the full set of activities associated with the CVC's verification procedures used for making the Conservation Projections for the 12-HD Program.

VERIFICATION OF CONSERVATION ELEMENT

The only Conservation Element for the 12-HD Project is the *Reduced Farm Deliveries (12-HD)*. The following set of terms and their definitions is presented to facilitate the discussion of the CVC's Y2K Inference Model and computational procedures for estimating the *Reduced Farm Deliveries (12-HD)*:

Sub-set. A sub-set of the 12-HD events defined by water application method, order size and season.

Savings/Event, AF. Average reduction in farm delivery per event in each *Sub-set* during the 1994 Water Year (when the 1:10 12-HD Database[2] was developed).

$(v_c)_m$. The *Savings/Event* in *Sub-set "m"*, which is the average reduction in farm delivery per event in *Sub-set "m"* during the 1994 Water Year.

Savings, AF. Reduction in farm deliveries for the total number of 12-HD events in a *Sub-set* during the current Water Year.

$(V_c)_m$. The *Savings/Event* in *Sub-set "m"*, which is the reduction in farm deliveries for the total number of 12-HD events in *Sub-set "m"* during the current Water Year.

Events, #. Number of 12-HD events in the *Sub-set* during the current Water Year.

Gates, #. Number of gates from which the 12-HD events in the *Sub-set* were supplied during the current Water Year.

Events/Gate, #. Number of 12-HD events per gate in the *Sub-set* during the current Water Year.

1994 Events/Gate, #. Number of 12-HD events per gate in the *Sub-set* during Water Year 1994 (when the 1:10 12-HD Database was developed).

EPG Ratio. Ratio of the number of 12-HD *Events/Gate* in the *Sub-set* during the current Water Year compared to the number of 12-HD *Events/Gate* in the *Sub-set* during the 1994 Water Year (when the 1:10 12-HD Database was developed).

k Factor. A factor used with each 12-HD *Sub-set* in the algorithm that controls the rate and extent of the reduction in its *Savings* when the number of *Events/Gate* in the *Sub-set* during the current Water Year exceeds the number of its *1994 Events/Gate* (in the 1994 Water Year when the 1:10 12-HD Database was developed), ie. when its *EPG Ratio* is greater than 1.

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2 The 1:10 12-HD Database was developed for use in verifying the conservation savings for Project 9 and is discussed in detail in the *12-Hour Delivery Program VSR*, dated July 1999. It is based on information obtained by interviewing the person making every tenth 12-HD order during the 1994 Water Year.

$(k)_m$. The *k Factor* for *Sub-set "m"*, which is a factor used in the algorithm that controls the rate and extent of the reduction in its *Savings* when its *EPG Ratio* is greater than 1.

(Water) Delivery Detail Data. The digital IID records of farm water deliveries from November 1, 1996 to date.

Development of Primary Data for the Inference Model

The Y2K Inference Model for estimating the *Reduced Farm Deliveries* requires having estimates of the *Savings/Event, AF* for each of the *Inference Model Sub-sets* that are based on the net on-farm conservation (savings) for each of the 1656 recorded 12-HD events in the 1:10 Database. To do this required following the steps outlined earlier. Key computational components were to estimate probable effective utilization (EU) of unneeded water depending on the responses to the query concerning each 12-HD. Then to compute the estimated net on-farm savings for each 12-HD, (v_c).

Effective Utilization (EU). It was assumed that a portion of the estimated gross on-farm conservation from a given 12-HD, (v_{24} - v_{12}), may have been effectively used. To account for this, Effective Utilization (EU) percentages were developed for each type of 12-HD order in the 1:10 Database and the estimated gross on-farm conservation savings were reduced by multiplying them by (1.00 - EU/100) to obtain the net savings. The EU percentage was developed from the answers given to the following two part question (see Appendix A, Item 18 on Form 1):

Part 1: If 12-HDs were not available, with the flow rate you indicated that you would have ordered for 24 hours do you think you would end up with too much water for this irrigation?

Part 2: If yes, where would the excess water have gone ? (Growers were given the following choice of destinations: same field, SF; directly to the drain, D; another field, same gate, SG; different gate, DG; back to canal, C; or other.)

The results of the development of the specific EU values for use in the general equation for estimating the *Savings/Event* value associated with each 12-HD event are presented in Appendix A, Table 4.

Since the development of the original Effective Utilization (EU) values, new insights for handling the 1:10 Database queries regarding the destiny of excess water with the farmer responses of "back to canal", (C) were developed. Using the new insights to develop a better analytical basis for estimating the potential EU for the "return to Canal" events in the 1:10 Database resulted in a higher EU, which decreases the average net on-farm savings accordingly. The resulting final EU values are presented in Appendix B, Table A-2, which is formatted the same as Table 4 in Appendix A. The estimated overall or global volume weighted average EU = 16.0 % for the 12-HD events in the 1:10 Database. Thus on average the (v_c) is the gross on-farm savings per 12-HD times (1.0 - 0.16).

Estimating the Saving for Each 12-HD in the 1:10 Database. The general equation for estimating the net on-farm conservation savings associated with each 12-HD event in the 1:10 Database, (v_c), is:

A. For $(t_{24} \times Q_{24})$ greater than $(t \times Q_{12})$;

$$(v_c) = (1/12.1)(1 - \%EU/100)[(t_{24} \times Q_{24}) - (t \times Q_{12})]$$

B. For $(t_{24} \times Q_{24})$ less than or equal to $(t \times Q_{12})$;

$(v_c) = 0$, when t less than 14.5 hours

and

$(v_c) = (1/12.1)(1 - \%EU/100)[(24 \times Q_{12}) - (t \times Q_{12})]$, when t greater than or equal to 14.5 hours

in which[3]:

(v_c) = estimated volume of water conserved for each 12-HD event in the 1:10 Database, AF

EU = estimate of excess 24-HD water that would have been effectively utilized, %

Q_{24} = estimate of probable 24-HD rate of flow if 12-HD was unavailable, cfs

t = actual duration of each 12-HD irrigation event, hr

t_{24} = 24 for all "M and S Class" orders, hr
24 for "H and h Class" orders for $t \leq 12$ hr, hr
$2 \times t$ for "H and h Class" orders for $t \geq 12$ hr, hr

Q_{12} = rate of flow delivered, Q_d , to fill the 12-HD order, O_{12}, as estimated by the zanjero/night-patrolman, except where no Q_d is given or Q_d deviates more than ± 25% from O_{12}, in which case $Q_{12} = O_{12}$, cfs

The entire 12-HD 1:10 Database was analyzed to estimate the net on-farm conservation savings associated with each 12-HD event, (v_c). The results of this analysis prior to revising the EU values are summarized in Appendix A, Table 5. The results for each method of irrigation and order class along with the respective order counts, durations, and order sizes (or flow rates) and the respective savings are summarized in the top five windows. Average savings for each of the irrigation methods were used in developing an inference model for

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3 The various order classes represent the sizes of the 24-HDs that were replaced compared to the sizes of the 12-HDs that replaced them. The main 12-HD order classes were: **Half or "H Class" orders** when the growers said their 12-HD replaced a 24-HD order that would have been ***exactly half*** of what they ordered for 12 hours; **half or "h Class" orders** when the 12-HDs were ***a little more than half*** of the 24-HDs they replaced; **Same or "S Class" orders** when the 12-HDs replaced 24-HDs that would have been ***exactly the same***; and **Minimum or "M Class" orders** that fall ***between "h and S Class" orders***.
The difference between Q_{12} and O_{12} is: Q_{12} refers to the rate of flow delivered to serve a 12-HD; and O_{12} refers to the rate of flow ordered for a 12-HD.

estimating the conservation savings for the District-wide use of 12-HDs. The averages for each order class and the overall averages for the entire 1:10 Database are summarized in the bottom window.

Y2K Inference Model Development

After developing a net on-farm water savings value for each 12-HD event in the 1:10 Database (v_c), the next step was to develop an inference model (or set of algorithms) to translate these estimated (v_c) to the *Reduced Farm Deliveries* for the current Water Year. This requires using the information available in IID's *(Water) Delivery Detail Data* for the 1994 and current Water Years which is stored in IID's Water Information System (WIS).

Excluding the Extra 12-HDs to Project 14 and 18 Fields. Farmers operating Drip, Linear Move Sprinkler, and Tailwater Recovery Systems order more 12-HDs than they would otherwise order for an average combination of the farm irrigation systems used throughout the IID service area. Some of these high 12-HD usage systems are sponsored by the IID/MWD Conservation Program falling under Projects 14 and 18, which receive credit for their on-farm Conservation Elements. Therefore, the additional 12-HDs induced by Projects 14 and 18 are not credited to 12-HD Program[4] and are excluded from the 1994 and current Water Year Databases[5]. (For details on the number of such 12-HDs involved and the effect that not excluding them would have when computing the *Reduced Farm Delivery* see pages A-26 and A-27 in Appendix B.)

Early Inference Models. The early inference models developed for estimating the *Reduced Farm Delivery* are presented in Appendix A. We will refer to the last of these models as the 1996 Inference Model. It is a simple model and relatively easy to understand. It has a simple set of algorithms that are similar to the more complex algorithms used in the CVC's Y2K Inference Model that will be used to estimate the R*educed Farm Delivery* for Year 2000 and subsequent Calendar Years thereafter. In view of this, to enhance understanding of the Y2K Inference Model a review of the 1996 Inference Model is presented below.

Since the development of the 1996 Inference Model in September 1996, all morning (AM) 12-HD orders during the fall (September through November) and spring (March through May) quarters were limited to a maximum of 5 cfs (5 cfs Cap) instead of the old standard 7 cfs Cap. This resulted in a decrease in the average net on-farm savings per 12-HD compared to when the 1:10 Database was developed in 1994. In addition there was concern about the effect of the significant growth in the use of 12-HDs since the 1994. To handle the 5-cfs Cap and growth in 12-HD usage the CVC developed the Y2K Inference Model for estimating the *Reduced Farm Delivery* based on the 1:10 Database.

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4 This is necessary because it is not acceptable to have the induced or potential spillage from one Project be Conserved (Saved) by another Project and count as Savings in the same Conservation Program, this in effect would be double counting.

5 On the other hand, the potential *Shutoff-loss per12-HD* for each of these 12-HDs that occurs on non-intercepted laterals is included as a part of the *Induced Lateral Spillage* for the 12-HD Program. Therefore, the *Shutoff-loss per12-HD* for the additional 12-HDs are not included as a Consequential Effect Element in the estimates of the Net Conservation Savings for the of Drip, Linear Move Sprinkler, or Tailwater Recovery Systems sponsored under Projects 14 and 18.

1996 Inference Model. The 1996 Inference Model has a simple algorithm that utilized six *Sub-sets* of the 1656 individual (v_c) values for the 1:10 Database developed during the 1994 Water Year. In developing this model a total of 17 *Sub-sets* based on irrigation method, crop, and season were identified. An analysis of variance indicated that the 17 *Sub-sets* could be combined into a minimum of three *Sub-sets* with significantly different mean values. However, rather than collapse the grouping to the minimum of three, it was decided to maintain a grouping convention that observed the different irrigation methods. This approach yielded the following six *Sub-sets* and average (v_c) values for each of them (based on the initial EU values):

$(v_c)_{F1}$ = 2.746 AF for flat (border irrigated) alfalfa from May through August
$(v_c)_{F2}$ = 1.817 AF for all other flat irrigated crops and seasons
$(v_c)_{R1}$ = 2.133 AF for all row irrigated crops except vegetables during January-August
$(v_c)_{R2}$ = 1.645 AF for row irrigated vegetables during January-August
$(v_c)_S$ = 2.122 AF for all sprinkler irrigations
$(v_c)_D$ = 1.718 AF for all drip irrigations

The 1996 algorithm for making future estimates of the *Reduced Farm Delivery* was the sum of the total net on-farm savings $(V_c)_m$ for each of the above six *Sub-sets*. With the $(V_c)_m$ for each *Sub-set* calculated by multiplying the appropriate $(v_c)_m$ value (based on the 1:10 Database) by the number of events in that *Sub-set,* taken from the district-wide *(Water) Delivery Detail Data* recorded in the WIS for the current Water Year. Table 7 in Appendix A contains a breakdown of the intermediate computations for estimating the Projected *Reduced Farm Delivery* for the 1996 Calendar Year based on 12-HD data for the 1995 Water Year.

The CVC pointed out that the 1996 Inference Model would be valid for the types of 12-HD uses that existed under the IID rules governing 12-HDs during the 1994 Water Year when the 1:10 Database was developed. Thus the rule change of limiting the maximum 12-HD delivery rate to 5 cfs (5 cfs Cap) during the spring and fall months beginning with of the 1996 Water Year was expected to affect the way farmers use 12-HDs and the associated savings. For example, the 7 cfs Cap operating rule used up through the 1995 Water Year provided water savings potential while discouraging 12-HD use for only labor savings. However, the lower 5-cfs Cap could limit a type of 12-HD use that was more prevalent under the 7-cfs Cap.

In view of the above, the CVC suggested that for verification purposes the following be done: 1) examine the potential impacts of any proposed rule change before it is made; 2) document any changes that may be adopted; and 3) develop appropriate modifications to the Inference Model to cover possible changes in 12-HD usage. In response to 1) and 2) the CVC examined and documented the potential impacts of the 5 cfs Cap. In response to 3) a 1:10 Grower 5 cfs Order Query activity was initiated to determine how many of the 4, 4.5, or 5 cfs 12-HD orders would have been placed as 5.5, 6, 6.5, or 7 cfs orders if they were still available during the Spring and Fall. The data obtained form this new query provided useful insights concerning the effects of the 5-cfs Cap . However, the 5-cfs Limitation Database was not directly used in the algorithms for the subsequent inference models.

Handling the 5-cfs Cap. The 5-cfs Cap on morning (AM) orders beginning with the spring of 1996 (and every spring and fall thereafter) resulted in significantly altering the relative numbers of orders in the order (size in cfs) tiers above 4.5 cfs as compared to when the cap was 7-cfs. Table A-3 in Appendix B shows the comparisons of the counts in each order tier in the 1:10 Database developed before the 5-cfs Cap and the District-wide Database (QTDB) for the period November 1, 1995 through October 30, 1996. Table A-4 in Appendix B shows the average net on-farm savings per 12-HD by order tier annually and by season derived from the 1:10 Database. The differences between the savings for any given order tier are fairly large in some cases, which is probably due to the different crops and irrigation methods that predominate in any given season. Based on considerations made form these two tables the CVC decided to maintain both 12-HD order size and "seasonality" as much as possible in the inference model.

The general equation for the inference model is (ignoring the effects of the increased 12-HD usage) is:

$$\text{Total Savings} = [n_1 \times (v_c)_1] + [n_2 \times (v_c)_2] \;\ldots\ldots\ldots\; +[n_m \times (v_c)_m]$$

where:

$n_1, n_2, \ldots\ldots n_m$ represent the number of 12-HD events in a given *Sub-set* of the 1:10 Database, and
$(v_c)_1, (v_c)_2, \ldots\ldots (v_c)_m$ represent the average savings per event in each *Sub-set*.

A constraint to the development of an inference model is the database size coupled with the necessity of having a sufficiently large threshold number of events in each of its *Sub-sets* to obtain statistically reliable average savings values, $(v_c)_m$, for each of them. A statistically reliable threshold is roughly 30 events per *Sub-set* and the 1:10 Database contains data for 1656 12-HD events. Therefore, even if the 12-HD events were equally distributed among *Sub-sets* the maximum number of *Sub-sets* would only be 1656/30 = 55.

In view of observations related to Tables A-3 and A-4 in Appendix B, a logical starting point for developing the inference model would be to divide the 1:10 Database into *Sub-sets* representing: the four irrigation methods; the four seasons; and the seven order tiers represented. However, this would result in having too many (4 x 4 x 7 = 112) *Sub-sets*. The first effort at reducing the number of *Sub-sets* was to consolidate the order tiers into three groups designated as: 1 to 4, for orders from 0.5 to 4.0 cfs; 5, for 4.5 and 5.0 cfs orders; and 6 to 7, for orders of 5.5 cfs or larger. The logic behind consolidating the 1 to 4 tiers is based on the fact that the 5 cfs Cap did not greatly affect the numbers of orders of 4 cfs or less and the average annual savings for the orders larger than 5 cfs are nearly the same (see Appendix B, Table A-3). Consolidating the order tiers into three groups reduced the number of possible data *Sub-sets* to 48. The 1:10 Database was divided into these 48 *Sub-sets* and the average savings per event in each *Sub-set* with 2 or more entries (or counts) was determined. The results of this screening process are presented in Appendix B, Table A-5.

Many of the *Sub-sets* presented in Table A-5 have too few events to provide statistically reliable $(v_c)_m$ values. So the next step in developing the inference model was to strategically combine the *Sub-sets* so each had over 20 (preferably 30) events and the uniqueness between *Sub-sets* was preserved as much as practical, as measured by the $(v_c)_m$, while considering the number of events involved. This combining process resulted in the 22 Inference Model *Sub-sets* of the 1:10 Database presented in Appendix B ,Table A-6. Following are examples of the kinds of 12-HD events included in each of the Inference Model *Sub-set* for the descriptors listed in the left hand column of Table A-6:

Sub-set Number	Descriptor	Kinds of 12-HD Events
2	flat1_4spf	flat irrigation with delivery rates between 0.5 to 4.0 cfs in the spring and fall
15	row5wsu	row irrigation with delivery rates of 4.5 and 5.0 cfs in the winter and summer
22	sp6_7	sprinkle irrigation with delivery rates between 5.5 to 7.0 cfs in all seasons of the year

The $(v_c)_m$ (based on the 1:10 Database) and the number, n, of IID's district-wide12-HD events for the corresponding *Sub-set* category (based on the 1996 Zanjero District-wide Database) were used in the general inference model equation[6] presented above to compute the Total (*Reduced Farm Delivery*) of 42,806 AF (see Table A-6).

Handling the Growth in 12-HD Usage. The 22 Sub-set Inference Model for estimating the net *Reduced Farm Delivery* based on the 1:10 Database. needed to be modified to handle the growth in 12-HD usage. It seemed logical that the average savings per 12-HD would be lower for additional events, except in the case of the increased acreage under drip and sprinkle irrigation. This is because the types of 12-HD uses rendering the largest savings would likely have been captured by the 12-HD Program early on. Therefore, more and more of the 12-HDs may be focused on labor and management savings with less potential for water savings.

Based on an analysis of the *(Water) Delivery Detail Data* and field visits (see Figure A-2, Table A-7 and the accompanying text in Appendix B) it appeared that the growth in usage has occurred in the following three domains. Firstly, there has been a significant **increase in usage of small** (0.5 to 2 cfs)12-HD orders to serve the expanding number of drip and sprinkle irrigation systems and small surface irrigated fields. Secondly, there has been some **extensive growth** with 12-HDs being made to a larger number of delivery *Gates* during any given season of the year. Thirdly, there has been **intensive growth** as the average number of *Events/Gate* (that is the total number of 12-HDs divided by the total number of farm delivery gates receiving 12-HDs) has increased, while the number of gates receiving 12-HDs has remained relatively constant (see Appendix B, Figure A-2).

Accommodating the Increased Usage of Small 12-HD Orders. The Inference Model that was designed to handle the 5 cfs Cap had 22 regular *Sub-sets* described by irrigation method, delivery rate, and season of the year, plus in effect a 23rd *Sub-set* for all 12-HD for which the irrigation method was unspecified in the 1:10 Database. The12-HD orders that were equal to or less than 4 cfs were grouped together in a single order tier that included all 0.5, 1, 1.5, 2, 2.5, 3, 3.5, and 4 cfs orders (for example, see *Sub-set* Number 2 in the above table). This was satisfactory as long as the relative distribution of order sizes remained the same as in 1994 when the 1:10 Database was developed. However, the relative numbers of small sized orders has increased significantly, especially the 1 and 2 cfs 12-HD orders.

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6 A special *Sub-set* was created for the 12-HD events for which the method of irrigation was unspecified. It is assigned an Average (v_c) of 1.947 AF based on the Weighted Average (v_c) of the other 22 *Sub-sets* in the 1:10 Database. Thus in effect there are 23 *Sub-sets* in the Inference Model.

In view of the above, four new *Sub-sets* of the 1:10 Database were created by combining all 0.5, 1, 1.5, and 2 cfs orders, regardless of the irrigation method or season, to handle the relative increase in small orders. This maintained the same integrity of the inference model since there is still the same minimum number (23) or more events in each of the Inference Model's *Sub-sets* (see Appendix B, A-8). Table A-9 shows the comparison between using the new 27 and previous 23 *Sub-sets* in the Inference Model to estimate the *Reduced Farm Delivery* using *(Water) Delivery Detail Data* from the WIS for the 1997 CFS Water Year(July 1 - June 30) and the revised EU values.

Accommodating Extensive Growth in Usage of 12-HDs Since 1994. The criteria that separates extensive from intensive growth is based on the number of *Events/Gate* in each *Sub-set*. Any growth in 12-HD usage is considered to be **extensive** if the number of *Events/Gate* in a *Sub-set* for the current Water Year is **less than or equal to** the *1994 Events/Gate* (see glossary above) for the corresponding *Sub-set* of the 1:10 Database. If there is no growth or the growth is extensive then **no reduction** in *Savings* is made for that *Sub-set* of the Inference Model. Thus if the *EPG Ratio*, which is the ratio of the *Events/Gate* to the *1994 Events/Gate* is less than or equal to 1.0 for a given *Sub-set*, no adjustment is made in the conservation savings for that *Sub-set*. (In shorthand form, if the *EPG Ratio* is less than or equal to 1.0, no reduction is made in $(V_c)_m$).

Accommodating Intensive Growth in Usage of 12-HDs Since 1994. Growth in the usage of 12-HDs in any *Sub-set* is considered to be **intensive** if its *EPG Ratio* is **greater than** 1.0, in which case **a reduction** algorithm is applied during the calculation of $(V_c)_m$, for that *Sub-set "m"* of the Y2K Inference Model. In the reduction algorithm, if its *EPG Ratio* is between 1 and its *k Factor*[7] (see glossary above) the *Events, #* for the *Sub-set* is separated into: Set A, with full-savings and Set B, with reduced-savings.

Set A. The number of 12-HDs assigned to Set A is the *Events, #/EPG Ratio*, and its contribution to the *Savings* for the *Sub-set* is its *Savings/Event, AF* multiplied by the number of 12-HDs assigned to it.

Set B. The remaining number of 12-HDs is assigned to Set B, and its contribution to the *Savings* for the *Sub-set* is its *Savings/Event, AF* multiplied by the number of 12-HDs assigned to it. This product is then reduced by multiplying it by a linear reduction factor, which is:
k - (*k* - 1)/2 - *EPG Ratio*/2 for the Sub-set.

(For a numeric example of the above, see Footnote[8].)

In the reduction algorithm, if its *EPG Ratio* is greater than its *k Factor*, the *Events, #* for the *Sub-set* is separated into: Sets A, with full-savings; Set B, with reduced-savings, and Set C, with no-savings.

Set A. Set A's contribution to the *Savings* for the *Sub-set* is computed the same as the above Set A.

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7 The establishment of the *k Factor* for each *Sub-set* is presented below.

8 Assume: *EPG Ratio* = 1.50; *k Factor* = 2; and *Events, #* = 1200 for a *Sub-set*. Since the *EPG Ratio* is greater than 1 and less than the *k Factor* the 1200 *Events* are separated into the Set A with full-savings and Set B, the remaining part, for which a linear reduction factor is applied. Set A (full-savings part) contains 1200/1,50 = 800 of the *Events*, thus Set B (reduced-savings part) contains the remaining 1200 - 800 = 400 of the *Events*.

Set B	The number of 12-HDs assigned to Set B is the *Events, #(k Factor - 1)*, and its contribution to the *Savings* for the *Sub-set* is its *(Savings/Event, AF)*/2 multiplied by the number of 12-HDs assigned to it.
Set C	The remaining number of 12-HDs is assigned to Set C and no contribution to the *Savings* for the *Sub-set*.

The reduction algorithm described above is depicted in Appendix B, Figure A-3 for the extensive and intensive portions of the growth in 12-HD events. The horizontal portion in Figure A-3 represents the entire extensive portion of usage where the savings per 12-HD event is equal to the $(v_c)_m$ in which the subscript *"m"* represents the *Sub-set* under consideration The sloped portion represents the portion of usage where the savings per additional 12-HD is decreased linearly from the full value of $(v_c)_m$ to zero, with the rate of decrease dependent on the value assigned to k_m *Factor* for each *Sub-set "m"*.

Establishing the *k Factors*. The CVC gained a subjective "sense" for the types of 12-HD usage in *Sub-sets* experiencing intensive growth from the analysis of the *(Water) Delivery Detail Data* and the field studies mentioned above. This "sense" was used to arrive at *k Factors* for each of the 27 Inference Model *Sub-sets*. The *k Factors* are either 1.5 or 2.0, with 2.0 being used for all 5-cfs, all drip and sprinkle, and all 0.5- 1-, 1.5, and 2- cfs *Sub-sets* (see Table 1). The logic for using the higher *k Factor* of 2 (which has the lesser effect on reducing savings) for these *Sub-sets* is as follows: for the 5-cfs *Sub-sets* it is because the 5-cfs Cap effectively forced their growth; for the drip and sprinkle *Sub-sets* it is because more crops are being fully grown under drip and sprinkle irrigation than in 1994; and for the all 0.5- , 1-, 1.5-, and 2-cfs *Sub-sets* it is because they contain increasing numbers of 12-HDs serving drip, sprinkle, and row irrigated small-fields that require specialized irrigation management.

Y2K Inference Model Algorithms. The Y2K Inference Model is based on the 27 inference *Sub-sets* with an average *Savings* for each *Sub-set "m"* of $(v_c)_m$, derived from the 1:10 Database (see Appendix B, Table A-8). It is designed to handle both the extensive and the intensive growth of 12-HD usage since the 1:10 Database was developed in 1994 as described above. The Model's three algorithms are expressed visually in Figure A-3 and in mathematical terms on page A-23 in Appendix B[9] to determine the AF of *Savings* for each *Sub-set "m"*, $(V_c)_m$.

Using the Y2K Inference Model to Determine the Reduced Farm Delivery

The *Reduced Farm Delivery* for the current Water Year is the sum of the of the individual AF of *Savings*, $(V_c)_m$, for each of the 27 Inference Model *Sub-sets* (see Table 1, which is for the 1998 Water Year). The sources of the data in the columns in Table 1 are:

- The *Sub-set* column contains the descriptors that identify the portions of the12-HD information or databases that contain the necessary data for a given row in the table. These descriptors are fixed in the Y2K Inference Model.

  - The data in following columns are fixed values in the Y2K Inference Model:

[9] The figure and equations happen to be set up in terms of the 1997 Water Year (indicated by terms with subscripts of 97), which was the current Water Year at the time Appendix B was written.

Table 1. The *Reduced Farm Delivery* for the 1998 Water Year Showing the Summation Process for the Individual AF of *Savings*, $(V_c)_m$, for Each of the 27 Inference Model *Sub-sets*.

Computed Reduced Farm Delivery Due to 12-HDs Provided Outside of Interceptor Areas for the Water Year Immediately Preceding the Calendar Year for which the Water Conservation Savings Projection is Made.								
Sub-set	Events, #	Gates, #	Events/ Gate, #	Saved/Event, AF	1994 Events/ Gate, #	k Factor	Savings, AF	EPG Ratio
1. drip3_7	545	56	9.7	2.25	10.3	2	1226	0.94
2. flat3_4spf	709	397	1.8	1.464	1.6	1.5	1025	1.12
3. flat3_4wsu	735	407	1.8	1.672	1.6	1.5	1211	1.13
4. flat5spf	1621	922	1.8	1.77	1.3	2	2737	1.35
5. flat5wsu	812	511	1.6	2.399	1.3	2	1909	1.22
6. flat6_7f	73	59	1.2	2.49	1.2	1.5	182	1.03
7. flat6_7sp	144	121	1.2	1.928	1.5	1.5	278	0.79
8. flat6_7su	1220	782	1.6	2.565	1.6	1.5	3129	0.98
9. flat6_7w	292	255	1.1	2.143	1.2	1.5	626	0.95
10. row3_4f	623	354	1.8	1.859	1.5	1.5	1129	1.17
11. row3_4sp	889	330	2.7	1.609	2	1.5	1303	1.35
12. row3_4su	214	117	1.8	1.81	1.3	1.5	342	1.41
13. row3_4w	776	395	2.0	1.651	2.3	1.5	1281	0.85
14. row5spf	1344	646	2.1	2.049	1.6	2	2658	1.3
15. row5wsu	731	374	2.0	2.515	1.7	2	1821	1.15
16. row6_7f	55	39	1.4	3.02	1.3	1.5	165	1.08
17. row6_7sp	105	84	1.3	2.586	1.8	1.5	272	0.69
18. row6_7su	500	218	2.3	1.842	1.6	1.5	800	1.43
19. row6_7w	260	188	1.4	2.275	1.5	1.5	592	0.92
20. sp3_4	2292	539	4.3	2.033	3.6	2	4595	1.18
21. sp5	1604	392	4.1	2.298	2.8	2	3418	1.46
22. sp6_7	248	87	2.9	2.951	2.4	2	721	1.19
23. all0.5	703	101	7.0	0.43	5.4	2	292	1.29
24. all1	1742	270	6.5	0.784	4	2	1207	1.61
25. all1.5	921	255	3.6	1.267	4.8	2	1167	0.75
26. all2	2662	599	4.4	1.472	3.5	2	3806	1.27
27. unspecified	43	38	1.1	1.942	1.1	2	83	1.03
Totals	21,863						37,975	

- The data in the *Saved/Event, AF* column was determined form the analysis of the 1:10 Database;
- The numbers in the *k Factor* column were subjectively chosen by the CVC ; and
- The data in the *1994 Events/Gate, #* column was determined from an analysis of the entire 12-HD database for the 1994 Water Year.

- The data in the *Events, #*, and *Gates, #* columns are (automatically) sorted out of the *(Water) Delivery Detailed Data* stored in IID's Water Information System (WIS) by algorithms in the Y2K Inference Model. These data will differ for each current Water Year in the future.

- The data in the *Events/Gate #*, and the *EPG Ratio* columns are intermediate values (automatically) generated by algorithms in the Y2K Inference Model. These data are included to provide a means for determining relative change in 12-HD usage and will differ for each current Water Year in the future.

- The data in the *Savings, AF* column are the intermediate (by *Sub-set*) and Total *Reduced Farm Delivery*.

Sample Calculation. The following example of step-by-step calculations are presented to aid in the understanding of important algorithms of the Y2K Inference Model. The data is taken from Table 1 (which is based on 1998 Water Year data) and the numerical example is the determination of the *Savings, AF* for *Sub-set "24"*, i.e.$(V_c)_{24}$ (for all 1 cfs orders):

Step 1. Find the number of *1994 Events* = 816 and the number of *1994 Gates* = 205; therefore, the number of *1994 Events/Gate* = 816/205 = 3.98, rounded to 4.0 (during the 1994 Water Year).

Step 2. Analyze the *(Water) Delivery Detail Data* to find the number of *Events* = 1,742 and the number of *Gates* = 270; therefore, the number of *Events/Gate* = 1742/270 = 6.45 (during the current Water Year).

Step 3. Then compute the *EPG Ratio* = 6.45/4.0 = 1.62 and note that the *k Factor* = 2 and the Savings/Event for *Sub-set 24*, $(v_c)_{24}$ = 0.784 AF.

Step 4. Since the *EPG Ratio* = 1.61 is greater than 1 and less than the *k Factor* = 2, the 1742 *Events* in the *Sub-set* are separated into the part of the *Events* for which there is no reduction and the remaining part of the *Events* for which a linear reduction factor is applied . The no reduction part contains 1742/1,62 = 1082 of the *Events*, thus there are 742 - 1082 = 660 of the *Events* in the reduction part remaining.

Step 5. Since the $(v_c)_{24}$ = 0.784 AF, the portion of the *Savings* attributed to the no reduction part of the *Events* is 1082 x 0.784 = 848 AF.

Step 6 The portion of the *Savings* attributed to the reduction part of the *Events* would be 660 x 0.784 = 518 AF, but this must be multiplied by the linear reduction factor. The linear reduction factor is: *k* - (*k* - 1)/2 - *EPG Ratio*/2 , which for Sub-set 24 is equal to 2 - (2 - 1)/2 - 1.61/2 = 0.695. Thus the *Savings* attributed to the reduction part of the *Events* is 0.695 x 518 = 360 AF.

Step 7. The *Savings* attributed to all of the *Events* in *Sub-set 24* is the sum of the results of Steps 5 and 6, thus: *Savings* for *Sub-set "24"*, $(V_c)_{24}$ (for all 1 cfs orders) = 848 + 360 = 1208 AF.

VERIFICATION OF CONSEQUENTIAL EFFECT ELEMENT

The only Consequential Effect Element for the 12-HD Program is *Induced Lateral Spillage (12-HD)*. It is the extra lateral spillage that occurs in relation to the starting or terminating of 12-HDs. It mainly results from the delay in timing of lateral headgate flow decreases relative to farm delivery gate shutoffs. The delay in decreasing the headgate flow stems from the natural bias of the zanjeros or night patrolmen to have a little extra water available at the farm delivery gate to reduce the possibility of having shortages. Shortages upset irrigators, but a little extra water is usually welcome.

The following discussion related to estimating the *Induced Lateral Spillage (12-HD)* is based on information from the CVC's Final Report, *Canal Spillage Analysis in Support of Conservation Savings Verification for Projects 3, 8, 9, 15, and 17*, dated July 1999, which will be referred to as the "Final Canal Spillage Report".

Strategy for Estimating Induced Lateral Spillage. As mentioned earlier, the general strategy for estimating the *Induced Lateral Spillage* resulting from terminating 12-HDs outside of the *Normal Operating Window*, which is when ordinary 24-HDs are terminated, is to assign an average increment of lateral spillage for each 12-HD serviced from non-intercepted laterals. This spillage increment is called the *Shutoff-loss per 12-HD*. For example, if there were 10,000 12-HDs serviced from non-intercepted laterals in a given Water Year, and the *Shutoff-loss per 12-HD* = 0.25 AF for that Water Year, then the projected *Induced Lateral Spillage (12-HD)* = 2,500 AF for the following Calendar Year. For the most part, the differences between the annual estimates of *Induced Lateral Spillage (12-HD)* leading up to the this point in time are the result of the evolution of the development of the *Shutoff-loss per 12-HD*. The process described below will be used for making the Conservation Projection for 2000 and the Projections thereafter.

Lateral Spillage Data Analysis. An analysis was made of the spillage data available from the set of 12 *Verification Laterals*. (There were 96 lateral-years of data available from the eight Water Years of verification-quality lateral spillage data.) It was observed that there was a great deal of variability in the volume of spillage attributed to the termination of 12-HDs among the different laterals across the eight year of record. Statistical tests (such as spillage vs. total number of gates on lateral, total lateral spillage, and number of 12-HDs used per lateral) were performed to find an explanation for this spillage variation.

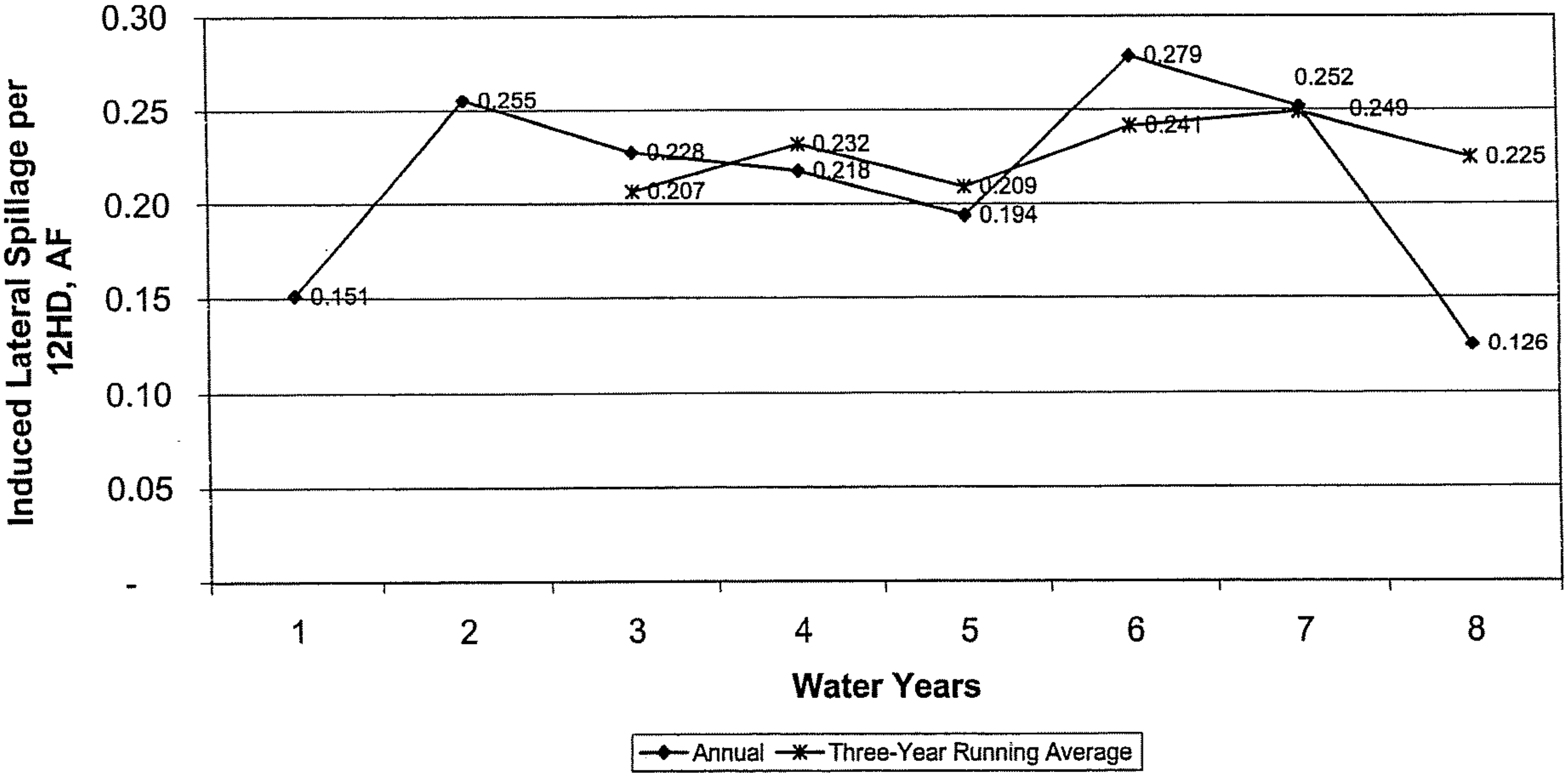
None of the statistical tests revealed significant correlation between the volume spilled per 12-HD and the above types of characteristics of the laterals and 12-HD usage. This indicated that the variability in the volume of lateral spillage per 12-HD is due to other factors than the physical parameters analyzed. Therefore, the CVC decided to use an annual lateral-by-lateral averaging technique based on all available verification-quality spillage data from non-intercepted laterals to compute the *Shutoff-loss per 12-HD*. Thus the makeup of the set of annual lateral spillage data varied from year to year (See Table 2).

Table 2. Laterals Spill Sites and Full Water Years of Verification-Quality Data Used to Compute the Shutoff-loss per 12-HD.

Sites and years used for 12hd spill tag using all available sites with full water years of data.
"1" indicates that this site is used for this water year.
Query hydro_cnl_spl_full_w_yr_final_sum from bpt>d:\1002\rev_spl\spl_anal9808.mdb for water years 1991 through 1998.

canal	1991	1992	1993	1994	1995	1996	1997	1998	Total Years	
B					1				1	
C					1				1	
D					1				1	
DAF							1	1	2	
E	1	1							2	
EBO							1	1	2	
EL13S	1	1	1	1	1	1	1	1	8	
ELDCA	1	1	1	1	1	1	1	1	8	
ELM3S								1	1	
ELMSA	1	1	1	1	1	1	1	1	8	
FIL	1	1	1	1	1	1	1	1	8	
MAY					1				1	
ML2					1				1	
MUL				1	1				2	
MUN	1	1	1	1	1	1	1	1	8	
MYR	1	1	1	1	1	1	1	1	8	
NET					1				1	
OLI	1	1	1	1	1	1	1	1	8	
ORA						1	1	1	3	
ORC	1	1	1	1	1	1	1	1	8	
PIN	1								1	
PLU	1								1	
POM	1								1	
R	1	1	1	1	1	1	1	1	8	
RED5S								1	1	
RED8S								1	1	
REDSA						1	1	1	3	
S	1	1	1	1	1	1	1	1	8	
SP						1			1	
SP5						1			1	
SP6SA						1			1	
STD				1	1				2	
T11						1			1	
T4						1			1	
T8						1			1	
T9					1	1			2	
V6	1	1	1	1	1	1	1	1	8	
WW	1	1	1	1	1	1	1	1	8	
Total Sites	16	13	12	14	21	21	16	19	132	
total days	5840	4745	4380	5110	7665	7665	5840	6935	48180	48180

Figure 1. Annual and 3-Year Running Average Shutoff-loss per 12-HD for all Laterals with Verification-Quality Hourly Spillage Data for the 1991 Through 1998 Water Years.



Shutoff-loss per 12-HD. Figure 1[10] is a plot of the average annual and 3-year running average *Shutoff-loss per 12-HD* for the 1991 through 1998 Water Years. It is based on the CVC's substitution process[11] for identifying the additional spillage caused by 12-HDs. The laterals comprising the data used in each year are listed in Table 2[12]. The annual yearly *Shutoff-loss per 12-HD* values vary from a high of 0.279 AF during 1996 to a low of 0.126 AF only two years later. This reduction is assumed to result from the additional swing shift (2 P.M. to 10 P.M.) zanjeros that were deployed by IID in 1998. As expected, the 3-year running average displays a dampened characteristic, ranging from a low of 0.207 AF to a high of 0.252 AF. The CVC has elected to use the 3-year running averages so the *Shutoff-loss per 12-HD* based on the 1998 Water Year data is 0.225 AF (see Figure 1).

Assuming the average 12-HD has a flow rate of 4.0 cfs, the average *Shutoff-loss per 12-HD* can be expressed as an average spillage duration. The *Shutoff-loss per 12-HD* (using the 3-year running average) translates to a range in flow duration from 38 to 46 minutes. This compare favorably with the independent computation in the Second Interim Canal Spillage Report, which is included as Appendix D in the Final Canal Spillage Report. In that report it was computed to be 0.21 AF for the *Verification Laterals* (then 13 rather than 12) during the 3-year period ending June 30, 1997. That computation was based on an assumed "response lag time", which represents the average mismatch in the timing of lateral headgate adjustment relative to closure of the farm delivery gate when a 12-HD is shut off. The response lag time was assumed to be between 30 and 90 minutes, depending on the time of day, with most 12-HDs falling into the period assumed to have a 30-minute response lag time.

Non-Intercepted Laterals. As mentioned above, the *Shutoff-loss per 12-HD* is only applied to 12-HDs served from non-intercepted laterals. The laterals that are not intercepted are listed in Table 3.

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10 Figure 1 is the same as Figure IV-7 in the above mentioned Final Canal Spillage Report.

11 Annual spillage volumes are computed for conditions that would exist if 12-HDs had not been used. To do this, lateral spillage-day types on which spillage could have been affected by 12-HDs are substituted with the spillage-day types that would have occurred if 12-HDs had not been available. Annual spillage volumes are re-computed using the mean spillage rates for the substituted spillage-day types. The computed "without-12-HD" annual spillage volumes are subtracted from the computed "with-12-HD" annual spillage volumes to determine the volume of spillage caused (or induced) by 12-HDs on each monitored lateral during each Water Year. These volumes are then totaled for all monitored laterals, and this total volume is divided by the total number of 12-HDs they served during the Water Year to obtain the *Shutoff-loss per 12-HD* (see Final Canal Spillage Report).

12 Table 2 is the same as Table II-1 in the above mentioned Final Canal Spillage Report.

Table 3. Imperial Irrigation District Laterals that are Not Intercepted Either Naturally or by Lateral Interceptor Projects (as of July 1999).

Table . Laterals that are not intercepted.

canal_name	canal_name	canal_name	canal_name
ACACIA	FILLAREE	NEW SPRUCE	SOUTH ALAMO
ALAMITOS	FLAX	NILAND EXTENSION	SOUTH DATE
ALDER	FORGETMENOT	NILAND LATERAL 1	STA
ASH	FOXGLOVE	NILAND LATERAL 2	STANLEY (& LAT 1)
BARTH	G	NILAND LATERAL 3	T
BEECH	GUNTERMAN	NILAND LATERAL 4	TRIFOLIUM EXTENSION
BES	H	NILAND LATERAL 5	TRIFOLIUM LATERAL 1
BEST	HEMLOCK	NILAND LATERAL 6	TRIFOLIUM LATERAL 13
BIRCH	HHL	NORTH DATE	TRIFOLIUM LATERAL 14
BIRCH LATERAL 1	HL	O	TRIFOLIUM LATERAL 15
BIRCH LATERAL 2 (P-2)	HOLT	O'BRIEN	TRIFOLIUM LATERAL 16
BIRCH LATERAL 2-A	I	OAK	U
BIRCH LATERAL 3	J	OAKLEY	VAIL LATERAL 1
BRIAR	K	OCCIDENT	VAIL LATERAL 2
BRYANT	L	OHMAR	VAIL LATERAL 2-A
C-WEST	LAVENDER	OLEANDER	VAIL LATERAL 3
COACHELLA	LAVENDER LATERAL 1	OLIVE	VAIL LATERAL 3-A
D-WEST	LILAC	ORANGE	VAIL LATERAL 4
DAFFODIL	LOTUS	ORCHID	VAIL LATERAL 4-A
DAHLIA	M	ORIENT	VAIL LATERAL 5
DOGWOOD	MAGNOLIA	ORITA	VAIL LATERAL 5-A
E	MALAN	OSAGE	VAIL LATERAL 6
EBONY	MALVA LATERAL 1	OSM	VAIL LATERAL 7
EHL LATERAL 10	MANSFIELD	OXALIS	W
EHL LATERAL 11	MAPLE	P	WALNUT
EHL LATERAL 12	MESA LATERAL 2	PAMPAS	WISTERIA
EHL LATERAL 13	MESA LATERAL 3	PANSY	WISTERIA P-1
EHL LATERAL 14	MESA LATERAL 3-D	PEACH	WISTERIA P-2
EHL LATERAL 16	MESA LATERAL 4	POE	WOODBINE
EHL LATERAL 5	MESA LATERAL 5	Q	WOODBINE LATERAL 2
EHL LATERAL 6	MESQUITE	R	WOODBINE LATERAL 3
EHL LATERAL 7	MGA	R SIDEMAIN	WOODBINE LATERAL 4
EHL LATERAL 8	MLA	REDWOOD	WORMWOOD
EHL SIDEMAIN	MOORHEAD	RICE	X
ELDER	MOSS	ROSE	Y
ELM	MUA	ROSELLE	YULE
EUCALYPTUS	MULLEN	RSS	Z
F	MUNYON	RUBBER	
FERN	MYA	S	
FERN SIDEMAIN	MYRTLE	SANDAL	
FIG	N	SIA	

ALLOCATION OF 12-HD SAVINGS BETWEEN PROJECTS 9 AND 15

A portion of the Net Conservation Savings associated with the 12-HD Program is allocated to Project 15, System Automation. As mentioned earlier, this is done because without the automated facilities provided under Project 15, it would not be both practical and possible to service the large number of 12-HDs without causing excessive delivery fluctuations at farm turnouts and excessive lateral spillage. Thus part of the *Reduced Farm Delivery (12-HD)* and part of the *Induced Lateral Spillage* is allocated to Project 15. Relative costs are used as the basis for the proportions allocated to each project as described below. (The cost data utilized below is for the 1998 calendar year.)

Annual Cost of Automation to Provide Flexible Deliveries

Operation and Maintenance Costs. The main System Automation components of Project 15 that are relevant to providing more flexible deliveries to farm turnouts include:

i. The automatic drop leaf gates in the check structures along the lower reaches of the Westside and East Highline Main Canals;

ii The automatic regulating and pumping facilities associated with the offline storage reservoirs along the three main canals;

iii The automatic regulating and pumping facilities associated with the lateral interceptor system storage reservoirs; and

iv The associated portions of the District-wide water management communications and control systems and the related portions of the Water Control Center.

These items are capital intensive and there is also a significant annual operating and maintenance cost associated with them. As of the end of 1997 the actual capital cost of facilities that are directly related to providing the flexibility needed for the 12-HD Program (and other 24-hour order flexibility being offered by IID) was estimated to be $5,904,331 expressed in 1988 dollars[13]. This compares to a total capital cost for automation of $11,310,012 expressed in 1988 dollars. Thus the ratio of the part attributed to providing delivery flexibility to the total is:

$$\$5,904,331/\$11,310,012 = 0.522.$$

The total projected annual O&M cost for all Project 15 facilities as of 1998 was approximately $450,000. Thus the portion of O&M costs related to providing flexibility is 0.522 x $450,000 = $234,900.

Capital Costs. To allocate conservation savings between Project 15 and 9 on a relative cost basis one logical method is to use their respective anticipated annual costs for the current calendar year. This requires annualizing the related Project 15 capital costs. To do this, first the cost in 1988 dollars must be escalated to

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13 Based on analysis of Program accounting records by IID and MWD staff as conveyed to the CVC September 25, 1997.

1997 dollars using the same construction cost index that was employed to deflate all capital expenditures back to 1988 dollars. That rate has averaged 3% over the 1988 to 1997 period[14]. Based on a 3% index, the appropriate multiplier (Compound Amount Factor) for the 10 year period is $(1 + 0.03)^{10} = 1.3436$. Thus the equivalent capital cost in 1997 dollars for the Project 15 facilities that are directly related to flexibility is:

$$1.3436 \times \$5{,}904{,}331 = \$7{,}933{,}059.$$

The next step is to annualize the current total capital cost over the n = 35 year life (following construction) of the IID/MWD Conservation Agreement. The appropriate multiplier (Capital Recovery Factor, CRF) for doing this using an interest (or discount) rate[15] of i = 8% is:

$$CRF = [i\ (1 + i)^n]/[(1 + i)^n - 1]$$

$$CRF = [0.8\ (1 + 0.08)^{35}]/[(1 + 0.08)^{35} - 1] = 0.08580$$

Thus the annualized capital cost is: 0.08580 x \$7,933,059 = \$680,656.

The projected 1998 O&M cost for all of the Project 15 facilities directly related to providing flexible deliveries is \$234,900 (see above). Thus the total projected annual capital and O&M cost for the Project 15 facilities directly related to providing flexible deliveries is:

Total Annual Cost = \$ 680,656 + \$234,900 = \$915,556.

Annual Cost of Providing 12-HDs

The way Projects 9 and 15 are configured, the costs associated with having additional labor and their travel (zanjeros, night patrolmen, hydrographers, and office staff) to manage the associated 12-HD water flow changes are the only charges made to Project 9. (Thus Project 9 is only charged for the direct O&M related to making the 12-HD flow changes because the necessary automation hardware and communication facilities provided by Project 15 are not included.) This direct O&M cost for 12-HDs is projected to be \$1,512,800 during calendar year 1998, which is \$62/12-HD for the anticipated 24,400 12-HDs. The total projected 1998 capital plus O&M costs for the related system automation of \$915,556, is equivalent to \$37.50/12-HD. Thus the total projected cost per 12-HD is \$99.50.

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14 By mutual agreement, IID and MWD have used the U.S. Bureau of Reclamation composite construction cost index (CCI) for computing comparable construction costs. Over the period 1988 to 1997, covering the majority of the Program's construction activity, the composite CCI averaged about 3% annually. Thus 3%, compounded over the 10-year period, is used in this computation to convert 1988 to 1997 costs.

15 By mutual agreement, IID and MWD have used a discount rate of 8% to compute equivalent annual costs from capital costs.

Allocating the Associated Conservation Savings

Based on the above, the total capital plus O&M cost for 12-HDs for 1998 is projected to be: \$1,512,800 + \$915,556 = \$2,428,356. Thus the portions (or ratios) of the Conservation Elements and Consequential Effects Elements that should be assigned to each part of the combined (9 and 15) Projects are:

For Project 9: \$1,512,800/\$2,428,356 = 0.623

For Project 15: \$915.556/\$2,428,356 = 0.377

These values are used for computing the portioning of the *Reduced Farm Delivery (12-HD)* between the Conservation Elements; and the proportioning of the *Induced Lateral Spillage* between the Conservation Consequential Effects Elements of Projects 9 and 15 respectfully. It is not intended that the above portions of 62.3 % for the Project -- 12-HD Program and the remaining 37.7 % for Project 15 -- System Automation be changed on an annual basis. Therefore, these proportions are set.

ANNUAL CONSERVATION PROJECTIONS

The analytical procedures underlying the Annual Conservation Projections for the 12-HD Program are presented above. These procedures are used to calculate the Conservation and Consequential Effects Elements for Project 9 and 15 (except for the *Prevented Main Canal Spillage (Fx24-HD)* for Project 15). The numerical values are for the 1998 Water Year, which is the *Current*[16] Water Year when this Verification Summary Report was finalized.

Calculation of Conservation and Consequential Effects Elements

Conservation Elements. The total *Savings* for each of the 27 *Sub-sets* of the Y2K Inference Model are added to obtain the Total *Reduced Farm Delivery (12-HD)* for the 12-HD Program for the 1998 Water Year (see Table 1). This Total of 37,975 AF is then prorated between Project 9 and 15 as follows in accordance with the ratio developed above:

Project 9: *Reduced Farm Delivery (12-HD)* = 0.623 x 37,975 AF = 23,658 AF

Project 15: *Reduced Farm Delivery (12-HD)* = 0.377 x 37,975 AF = 14,317 AF

Consequential Effects Elements. To calculate the Conservation Effect Elements for the two projects, first the appropriate number of 12-HDs must be determined. This is done by querying of the *(Water) Delivery Detail Data* for all of the IID laterals that are not intercepted (see Table 3). A query for the 1998 Water Year yielded 14,792 as the total number of 12-HDs that were served from non-intercepted laterals.

The next step is to calculate the *Shutoff-loss per 12HD* for the 1998 Water Year, which is the average value for the 3 Water Years of 1996, 1997, and 1998. Details of the strategy for doing this can be found in the CVC's Final Canal Spillage Report (see Figure 1, Table 2, and associated Text). From Figure 1, note that the three-year running average for the Induced Lateral Spillage per 12-HD , which is the *Shutoff-loss per 12-HD* = 0.225 AF.

Then compute the following:

Total *Induced Lateral Spillage (12-HD)* = 0.225 AF/Event x 14,792 Events = 3,323 AF

The final step is to prorate this Total of 3,323 AF between Project 9 and 15 in accordance with the ratio developed above as follows :

Project 9: *Induced Lateral Spillage (12-HD)* = 0.623 x 3,323 AF = 2,070 AF

Project 15: *Induced Lateral Spillage (12-HD)* = 0.377 x 3,323 AF = 1,253 AF

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16 Pertaining to the most recent Water Year for which there is a full year of data available in the *(Water) Delivery Detail Data.*

Conservation Projection Based on 1998 Water Year Data

After the end of each Water Year a projection of the Net Conservation Savings is made for the upcoming Calendar Year. For instance, the data used in the example calculations presented herein were based on 1998 Water Year data, thus the Net Conservation Savings based on the estimates of the Conservation and Consequential Effects Elements developed above would normally have been the same as the 1999 Conservation Projection for Project 9 – 12-Hour Delivery (12-HD) Program.

The above Conservation and Consequential Effects Elements are tabulated in Table 4, which is in the same tabular form as they would appear in the CVC's annual report titled, *Projected xxxx Water Conservation Savings With Supporting Documentation* form Project 9–12-Hour Delivery (12-HD) Program. However, because of minor adjustments in the queries and algorithms that have been made since issuing the 1999 Conservation Projections, the estimates of the *Reduced Farm Delivery (12-HD)* and *Induced Canal Spillage (12-HD)* presented in Table 4 are not quite the same as in the CVC's 1999 Annual Report. Thus to avoid confusion, with the previously submitted Conservation Projection, which is called the "1999 Conservation Projection", the estimates presented in Table 4 are referred to as "Conservation Projection Based on 1998 Water Year Data", which is 21,750 AF for Project 9.

Table 4. Project 9 -- 12 hour Delivery (12-HD) Program Conservation Projection Based on 1998 Water Year Data

Table 4
Project 9 -- 12-Hour Delivery (12-HD) Program
Conservation Projection Based on 1998 Water Year Data

Conservation Elements		Consequential Effect Elements		Net Savings
Description	(AF)	Description	(AF)	(AF)
Reduced Farm Delivery (12-HD) P9-1	*23,658*	Induced Main Canal Spillage (12-HD) P9-2	0	
		Induced Lateral Spillage (12-HD) P9-3	*2,070*	
Total	**23,658**	**Total**	**2,070**	**21,588**
Conservation Projection Based on 1998 Water Year Data				**21,590**

Notes:

P9-1 See details following page.

P9-2 Main canal spillage has been essentially eliminated through construction of the main canal reservoirs under the IID/MWD Agreement and by IID prior to the Agreement. Therefore, it is assumed that induced main canal spillage is zero. (However, if main canal spillage occurs for any reason at any of the four Program reservoirs that regulate main canal flow, that spillage is deducted from the savings of the associated reservoir. Those spill sites are associated with Projects 1, 4, 8 and 17.)

P9-3 12-HDs result in additional lateral spillage compared to the operational spillage associated with the 24-hour deliveries they replace. That additional lateral spillage is captured and conserved where laterals are intercepted and the water can be stored for future use. Of the estimated spillage that occurs from non-intercepted laterals due to 12-HDs during the water year immediately preceding the calendar year for which the water conservation savings projection is made, 62.3 percent is assigned to Project 9 and the remainder to Project 15.

INDEPENDENT VALIDATION ANALYSIS

The Initial VSR provides independent backup for the conservation estimate derived from the individual irrigation event based strategy that utilized the 1:10 Database of grower/irrigator's responses to the 1:10 12-HD queries conducted during the 1994 Water Year. For the individual event based strategy, which is depicted in the upper part of Figure 1 in Appendix A, the "inflow" differentials (for each 12-HD as compared to the 24-HD it replaced) is estimated for each irrigation of any "field" receiving a 12-HD. Thus it is a "single event" based strategy and the total conservation savings is the sum of the estimated conservation savings from each of the 12-HD events.

Two conservation savings estimating strategies were employed for the validation analysis, an analysis of *finish heads* and an analysis of *delivery-day differentials*. These validation techniques were based on "multiple event" strategies using "district-wide" differential "inflow" information and is depicted in the lower portion of Figure 1 in Appendix A. The order and delivery information stored in IID's WIS files was used for the validation analysis. The primary data source for this analysis was the most recent version of the "CFS Files" created through a query of IID's WIS files computer. These records include district-wide irrigation events for the CFS Years from July 1, 1986 through June 30, 1998.

Earlier Independent Validation Analysis

Validation analysis for both Finish Heads and Delivery-day Differentials were developed using data for the 1987 through 1995 CFS Year data (see Appendix A, pages 22 through 27. This analysis was updated to include data through the 1998 CFS Year (see Appendix B, pages A-28 through top of A-32). However, at that time the CVC elected to not use the data for the 1996 CFS Year for the Delivery-day Differential Analysis. This was because it was radically different than the data from the years to either side of it in that there were unusually high average 24-HD delivery rates[17], which may have been the result of the consolidation of the IID Divisions and the initiation of the 5-cfs Cap on 12-HDs. Subsequent to the presentation of the Updated Independent Validation Analysis (see Appendix B) the WCMC requested that the CVC include the 1996 CFS Year data and rerun the Delivery-day Differential Analysis. The results of this are presented below.

Update of Delivery-day Differential Analysis

An analysis of the CFS Files was made to separate the deliveries into three categories by annual delivery days and AF delivered for each of the past nine 12-month periods (beginning with July 1, 1986 through June 30, 1998). The three categories are: 24-HDs; 12-HDs; and combined 24-HDs and 12-HDs. The results of this query of the CFS Files are presented in Table 5 (this replaces Table A-13 in Appendix B).

The total number of order days (ODs) has not changed very much during the study period (see Table A-13). However, the average delivery per OD has decreased by approximately 0.21 AF/day (14.712 AF/delivery-day

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17 It is interesting to note that in 1996 the average delivery for 24-HDs was unusually high in spite of the fact that it should have been decreasing considering the additional flexibility provided for 24-hour deliveries. This may have been the result of the larger than normal areas in flat irrigated because of unusually favorable hay and wheat prices, the consolidation of the IID Divisions, the initiation of the 5 cfs Cap on the 12-HD Program, and uncertainties concerning future allocations of water.

for 1987 through 1989 less 14.502 AF/delivery-day for 1990 and 1998) even though the average delivery for 24-HDs has increased over the last nine years (see Table 5). This is practically the same as the difference obtained in the Delivery Differential Analysis in the Initial VSR for Part I[18].

The average 12-HD would need to be 6.0 AF/day for the post-12-HD project average delivery per OD to be the same as for the pre-project period. This is about 1.5 times the average volume delivered per12-HD, which is an indication that farmers are not generally abusing 12-HDs by simply replacing their small 24-HDs with 12-HDs having twice the flow rate and only using them for half as long.

Assuming the characteristics of the remaining 24-HDs have not changed appreciably, the difference in the average quantity of water, 0.21 AF/day, delivered per OD before the 12-HD Program began and during post project period from 1990 and 1998 can be used to estimate the average annual savings associated with the 12-HD Program (or the average savings per 12-HD). To do this the 0.21 AF/day is multiplied by 176,035 delivery-days (the average number of ODs per year during 1990 and 1998) to obtain an average delivery difference of approximately 37,000 AF between these pre- and post-12-HD Program periods. This delivery difference of 37,000 AF can be divided by 18,634 (the average number of 12-HDs during the 1990 through 1998 period) to obtain an average gross on-farm savings of approximately 2.00 AF for each 12-HD.

The revised volume weighted average (or global) effective utilization, EU = 16 % for the 1:10 Grower Database (see Table A- 2). Thus the average annual net on-farm savings per 12-HD based on the above analysis would be: (1 - 0.16) x 2.00 = 1.68 AF. This is approximately the same as the average net on-farm savings of 1.76 AF/12-HD estimated for the 1997 data based on the latest inference model and including all interceptor projects (see Table 5). However, it includes a very small reduced farm deliveries associated with Tailwater Recovery Systems (TRS) since the 12-HD Program began.

It is interesting to note that in 1996 the average delivery for 24-HDs was unusually high in spite of the fact that it should have been decreasing considering the additional flexibility provided for 24-hour deliveries. This may have been the result of the larger than normal areas in flat irrigated because of unusually favorable hay and wheat prices, the consolidation of the IID Divisions, the initiation of the 5 cfs caps on the 12-HD Program, and uncertainties concerning future allocations of water. In view of this it is interesting to carry out the above analysis by comparing the 1997 and 1998 data against the *Pre-project* period from 1997 through 1989 and the again with only the 1998 data against the pre-project data.

1997 -- 1998 Comparison. The average delivery per OD has decreased by approximately 0.32 AF/day (14.712 AF/delivery-day for 1987 through 1989 less 14.394 AF/delivery-day for 1997 and 1998), see Table 5. Thus the average 12-HD would need to be 6.2 AF/day for the post-12-HD project average delivery per OD to be the same as for the *Pre-project* period. This is over 1.5 times the average 12-HD, which as mentioned before is a strong indication that farmers are not generally abusing 12-HDs by simply replacing their small 24-HDs with 12-HDs having twice the flow rate and only using them for half as long.

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18 There are some discrepancies between the data presented in Table 9 in Appendix A and Table 5 for 1991, 1994, and 1995, especially for 1995. The CVC can not explain these discrepancies. Assuming the data presented in Table 5 is the most accurate, the average delivery per OD should have been 0.27 AF/delivery-day rather than 0.32 AF/delivery-day presented and used in the earlier analysis.

Multiplying the average reduction in delivery per OD of 0.32AF/day by 186,194 delivery-days (the average number of ODs per year during 1997 and 1998) gives an average delivery difference of approximately 59,600 AF between these pre- and post-12-HD Program periods. Dividing this delivery difference of 59,600 AF by 24,151 (the average number of 12-HDs during the 1997 and 1998 period) gives an average gross on-farm savings of approximately 2.47 AF for each 12-HD.

Using the EU = 16 %, the average annual net on-farm savings per 12-HD based on the above analysis would be: (1 - 0.16) x 2.47 = 2.08 AF. This is considerably higher than the average net on-farm savings of 1.76 AF/12-HD estimated for the 1997 data based on the latest inference model and including all interceptor projects (see Table 5). However, it includes the full impact of the reduced farm deliveries associated with Tailwater Recovery Systems (TRS) and the effects of the additional flexibility IID now offers for 24-HDs.

1998 Comparison. Based on a comparison of the *Pre-project* period and 1998, the average delivery per OD has decreased by approximately 0.66 AF/delivery-day (14.712 AF/delivery--day for 1987 through 1989 less 14.056 AF/delivery-day for 1998). The average 12-HD would need to be 8.8 AF/day for the post-12-HD project average delivery per OD to be the same as for the *Pre-project* period. This gave an average delivery difference of approximately 129,200 AF between these pre- and 1998 12-HD Program periods. Assuming 4,700 AF is TRS water and 40 percent of the remaining difference is due to Fx24-HD savings, the difference attributed to the 12-HDs would be roughly 75,000 AF. Dividing this difference by 23,985 (the average number of 12-HDs during the 1998 period) and adjusting for EU=16% gives an average gross on-farm savings of approximately 2.63 AF for each 12-HD. This is considerably higher[19] than the average net on-farm savings of 1.76 AF/12-HD estimated for the 1997 data based on the latest inference model.

In view of the above considerations the update of the Delivery-day Differential Analysis provides strong analytical and independent non-subjective support indicating that the estimated on-farm conservation savings derived from the 1:10 Grower Database may be on the low or conservative side.

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19 Part of this may be due to an increase in the number of small 24-HDs that serve the expanded acreage irrigated with drip and solid set sprinkle systems. This would reduce the average 24-HD even if the 12-HD Program were not in place and be partly responsible for the overall decrease in the average AF/delivery-day.

Table 5
Daily Volumes and Numbers of 24- and 12-HD Delivery-days Between 1987 and 1998

CFS Year (July 1 -June 30)	24-HD Deliveries			12-HD Deliveries			Combined 24-HD and 12-HD Deliveries		
	Ave Delivery (AF/day)	Number of Order Days	Total (AF)	Ave Delivery* (AF/day)	Number of Order Days	Total (AF)	Ave Delivery (AF/day)	Number of Order Days	Total (AF)
1987	14.731	155,278	2,287,400	4.941	183	904	14.719	155,461	2,288,230
1988	14.721	154,153	2,269,286	9.918	1	10	14.721	154,154	2,269,301
1989	14.698	177,389	2,607,264	N/A	0	0	14.698	177,389	2,607,264
1990	14.770	177,857	2,626,948	3.509	5,741	20,145	14.418	183,598	2,647,116
1991	15.244	158,856	2,421,601	4.472	14,759	66,002	14.328	173,615	2,487,556
1992	15.599	146,855	2,290,791	4.450	15,642	69,607	14.526	162,497	2,360,431
1993	15.500	139,013	2,154,702	4.172	16,401	68,425	14.304	155,414	2,223,042
1994	15.739	158,095	2,488,257	4.080	20,078	81,918	14.425	178,173	2,570,146
1995	16.127	156,181	2,518,731	4.195	22,143	92,890	14.645	178,324	2,611,555
1996	16.784	158,090	2,653,383	4.188	24,643	103,205	15.085	182,733	2,756,527
1997	16.391	161,083	2,640,311	3.733	24,316	90,772	14.731	185,399	2,731,113
1998	15.585	163,004	2,540,417	3.667	23,985	87,953	14.056	186,989	2,628,317
erage of 1987 - 1989	14.717	162,273	2,387,983				14.712	162,335	2,388,265
erage of 1990 - 1995	15.497	156,143	2,416,838	4.146	15,794	66,498	14.441	171,937	2,483,308
erage of 1996 - 1998	16.253	160,726	2,611,370	3.863	24,315	93,977	14.624	185,040	2,705,319
erage of 1997 - 1998	15.988	162,044	2,590,364	3.700	24,151	89,362	14.394	186,194	2,679,715
erage of 1990 - 1998	15.749	157,670	2,481,682	4.052	18,634	75,657	14.502	176,305	2,557,311
fference ('Ave 1987 - 1989' - 'Ave 1990 - 1998')							0.210		
The average 12-HD would have to be 6.016 AF for no change in the overall average delivery size. (Difference ('Ave 1987 - 1989' - 'Ave 1990 - 1998'))									
arget	15.749	157,670	2,481,682	6.016	18,634	112,109	14.712	176,305	2,593,791
fference ('Ave 1987 - 1989' - 'Ave 1996 - 1998')							0.088		
The average 12-HD would have to be 4.563 AF for no change in the overall average delivery size. (Difference ('Ave 1987 - 1989' - 'Ave 1996 - 1998'))									
arget	16.253	160,726	2,611,370	4.563	24,315	110,940	14.712	185,040	2,722,310
ifference ('Ave 1987 - 1989' - 'Ave 1997 - 1998')							0.318		
The average 12-HD would have to be 6.166 AF for no change in the overall average delivery size. (Difference ('Ave 1987 - 1989' - 'Ave 1997 - 1998'))									
arget	15.988	162,044	2,590,364	6.166	24,151	148,919	14.712	186,194	2,739,283
ifference ('Ave 1987 - 1989' - '1998')							0.656		
The average 12-HD would have to be 8.779 AF for no change in the overall average delivery size. (Difference ('Ave 1987 - 1989' - '1998'))									
arget	15.585	163004	2540417	8.779	23,985	210,562	14.712	186,989	2,750,979

Imperial Irrigation District

Metropolitan Water District of
Southern California

Water Conservation Agreement

INITIAL VERIFICATION PROCEDURE
for estimating
NET ON-FARM SAVINGS RESULTING FROM 12-HOUR DELIVERIES
to obtain
REDUCED FARM DELIVERIES (12-HD)
for projects 9 and 15

Conservation Verification Consultants

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INITIAL VERIFICATION PROCEDURE for estimating NET ON-FARM SAVINGS RESULTING FROM 12-HOUR DELIVERIES to obtain REDUCED FARM DELIVERIES (12-HD) for projects 9 and 15

Conservation Verification Consultants

June 30, 1999
(reprint)

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FOREWORD

The Initial Verification Summary Report (VSR) for the Part I: Net On-Farm Savings associated with the 12-Hour Delivery (12-HD) Program was finalized in September 1996. Since completing the Initial VSR for Part I a number of changes have been made and/or have taken place in the 12-HD Program. To address these changes an Addendum to the *Project 9 12-Hour Delivery Report, Part I: Net On-Farm Conservation Savings (Dated September 1996)* has been developed and is included herein. The first DRAFT of the Addendum was submitted to the WCMC at the June 20, 1997 meeting and discussed. However, at that time the section on limiting the 12-HD savings was incomplete. A second DRAFT of the Addendum containing a preliminary method for handling the growth of 12-HD usage and accounting for 12-HDs to serve Projects 14 and 18 was submitted at the January 28 1998 WCMC and discussed. However, this third DRAFT contains CVC's latest strategy for handling the growth in the usage of 12-HDs, an updated validation analysis, and an example computation for utilizing the a new inference model for determining the net on-farm savings associated with 12-HDs.

While the 12-HD Program generates large on-farm conservation savings, the management of the 12-hour deliveries results in additional lateral spillage compared to the normal operational spillage associated with the 24-hour deliveries they replace. This additional spillage is captured and conserved where laterals are intercepted and the potential spills are immediately available for use down steam or stored for future use.

In this VSR, Part II: Consequential Spillage associated with the 12-Hour Delivery (12-HD) Program is very short and only contains the necessary information for estimating the consequential spillage. This is because understanding and quantifying lateral spillage is an important aspect of conservation verification for five projects in the IID/MWD Water Conservation Program. These are the three interceptor projects, system automation, and the 12-HD Program. Therefore, it was most efficient to address lateral canal spillage as a general issue because these projects either target canal spillage for conservation or cause spillage to increase as a consequence of project operation as is the case for the 12-HD Program.

In view of the above the CVC elected to develop a separate study focused on canal spillage. The DRAFT Report, *Analysis of Canal Spillage in Imperial Irrigation District*, dated September 1997 and revised in 1998 contains a full description of the strategies used in developing the study and essential outputs resulting from it. Therefore, it was not necessary nor would it be efficient to include the details of that work herein.

There are three important Annexes for the this VSR that are bound separately, these are: 1) The Main Verification Report for Part I that contains the Underlying Data And Details; 2) The report on the 12-HD Verification Procedures Seminar; and 3) The Canal Spillage Report provide. Coupled with this VSR these reports provide a window into the full set of activities associated with verification of the water savings associated with the 12-HD Program.

PROJECT 9
12-HOUR DELIVERY PROGRAM
VERIFICATION SUMMARY REPORT

PART I:
NET ON-FARM SAVINGS
(Final dated September 1996)

This Verification Summary Report is a condensed version of the *Main Verification Report, Part I: Net On-Farm Conservation Savings* for Project 9. It lays out the strategies used in the full report but leaves out much of the detail. It is designed for the reader who needs more information than would be covered in an Executive Summary but does not wish or have time to explore all of the detail in the full report. The Main Report is the Annex referred to herein.

BACKGROUND

Section I of the Main Report provides a description of Project 9, which is the 12-hour Delivery Program. It also includes the background leading up to the current strategy and methodology for estimating the gross and net on-farm water conservation savings associated with it.

Three different processes including the current one have been employed to estimate the on-farm or direct conservation savings associated with Project 9. These processes all feature an event-based delivery differential strategy (or approach) to estimate the gross conservation savings realized from each 12-hour delivery, 12-HD:

$$v_c = v_{24} - v_{12}$$

where:

v_c	=	gross volume of water conserved for a given 12-HD event, AF
v_{24}	=	estimated volume of water that would have been delivered for the event without the 12-HD Program (the without-project delivery), AF
v_{12}	=	volume of water actually delivered for the event with the 12-HD Program, AF

This general strategy acknowledges that estimating the volume that would have been delivered, v_{24}, is in effect an informed judgement of what each farmer would have done if only 24-hour deliveries were available.

The CVC were asked to critique the first two 12-HD verification processes and the associated activities in early 1993. The initial process relied on the judgments of the Water Clerks in each of the six IID Divisions to specify the expected conservation savings, v_c, for each 12-HD. The second process involved selecting 12 cooperating growers, two from each division, and having the Assistant Division Superintendents query them to estimate the associated v_c for each of their 12-HDs in that Division.

When the CVC was asked to do this, the program and its verification had been in effect for about 3 years. Therefore, rather than proceed with development of an independent verification plan, the CVC choose to conduct a critique of ongoing verification activities. As a result of this critique the CVC suggested that a different data collection process be employed for estimating the conservation savings associated with each 12-HD event.

ESTIMATING THE NET ON-FARM CONSERVATION SAVINGS PER 12-HD EVENT

Section II of the Main Report covers the development of the strategy and basis used by the CVC for estimating the net on-farm water conservation savings, (v_c), associated with each 12-HD event. The associated on-farm savings do not account for the consequential effects of the 12-HD Program. The process of reducing the inflow of water to the laterals in a timely manner to accommodate the shut-off of each daytime 12-HD potentially increases the lateral and main delivery system operational spills. These consequential effects are dealt with in *Part II: Consequential Supply System Operational Losses*, which is a separate set (Main and Summary) of Reports.

In view of the CVC's concerns with using the data collected from the 12-Cooperating Growers to make the (v_c) estimates a new database and estimating procedure was recommended and initiated during the 1993-94 water year (beginning October 1, 1993 and terminated September 30, 1994). Instead of concentrating on a few selected growers who were large users of 12-HDs, a random query was made of all growers who placed 12-hour orders. To achieve this, each Division was asked to have its Water Clerks count the 12-HD orders in sequence as they arrived and complete a special Grower Questionnaire (see Form 1) for **every 10th 12-HD order**. This required querying the appropriate grower or irrigation foreman.

The above procedure produced a random sample of 12-HD users and uses. Besides asking, "If 12-HDs were not available, what would you have ordered for 24-hours?" they were also queried about what would have been done with any excess water and why they were using 12-HDs. In addition to these special Grower Questionnaires, a Zanjero Information sheet (see Form 2) to be filled out for **every 12-HD order** was also developed.

Several Superintendents and Water Clerks as well as 12-HD users were consulted during the process of developing Forms 1 and 2. The 1-in-10 (1:10) grower query program was begun in the middle of September 1993 to allow for a period of adjustment/learning before the full year of data collection began. During this learning period the CVC coached someone in each Division in the process required and revised the forms to make them more "user friendly".

The data required for filing in the Zanjero Information sheets (Form 2) must be collected through the life of the IID/MWD Conservation Agreement. This information is needed to keep track of 12-HD usage and to obtain necessary information for estimating the associated water conservation.

The most common 26 (out of 106) crops represent 90 percent of the district-wide 12-HD use (see Table 1). By comparing the 1:10 with the District wide counts it is apparent that the random sampling program was quite successful. The 1:10 Grower Database appears to be proportionally distributed across methods, seasons, Divisions, and crops (see percentages at bottom of Table 2).

FORM 1

12-Hour Delivery Program - Questionnaire for Every Tenth Order

Serial Number_______
(Water Resources)

Order Information - From Order Slip

1. Date of order: ______________
2. Account No.: ______________
3. Time of order: ______________
4. Division: ______________
5. Start date: ______________
6. Order: ______________cfs
7. Canal: ______ Gate: ______
8. No. of days of delivery: _____
9. Check One: __AM __PM
10. Crop Code: ______________
11. Grower: ______________
12. Phone Num: ______________

Interview Information

13. Name of interviewer: ______________

14. Total area served by this gate: ______________acres

15. Area to be irrigated with this order: ______________acres

~~16. What is the smallest head that can be used for this irrigation:~~ ____ OMIT THIS QUESTION ~~____cfs~~

17. **If 12-hour deliveries were not available, what would you have ordered for 24 hours:**________cfs

    Note: Enter the head value in cfs, or check one of the appropriate spaces below if the grower says:

    "half of the 12-hour order" ______H
    "same as the 12-hour order" ______S

18. Using this flow rate for 24 hours, do you think you would end up with too much water for this irrigation: ______No ______Yes

    If yes, where would the excess water have gone (check one):

    ___ Same field(SF) ___Directly to the drain(D)

    ___ Another field, same gate(SG)

    ___ Different gate (DG)

    ___ Back to canal (gate would have been closed) (C)

    ___ Other (specify): ______________

19. Why are you using a 12-hour delivery (check all **that apply**):

    ___ To improve irrigation performance (I)

    ___ Save water (S)

    ___ Convenience (C)

    ___ Save Labor (L)

    ___ Get better crop (B)

    ___ Save Money (M)

    ___ Other (specify): ______________

    ____

20. Would a 24-hour irrigation have suited your needs (check one):

    _____Yes _____No

21. Will this 12-hour delivery save you any water?

    _____ Yes _____ No _____ Don't Know

22. Comments: ______________

    ____

23. Actual Delivery Date: ______________

FORM 2
12-Hour Delivery Program - Zanjero Information

Instructions

Please fill out one of these sheets for every 12-hour irrigation that you delivery. This information is very important, so please be as accurate, neat, and complete as possible. We are asking you to fill this out because the Zanjero is the person in all of IID that has the best handle on this field information.

For questions 1 through 6 and question 9, please fill in the correct answer. For questions 7, 8, and 10, just check off the **one** answer that best applies. If you check off "other," then please fill in the blank. For questions 11 through 13, please enter the time in 24-hour (military) format. The start and end times may not be the time that the farm gate was actually opened or closed. You may have to estimate the time that the delivery actually began (started flowing through the gate) and ended. If the time was estimated, please enter a comment to indicate such (see coded comments on back).

If the delivery was not backed out of the lateral heading, please enter a comment to indicate where the returned 12-hour water went (see coded comments on back) Use question 14 to enter anything pertinent concerning the 12-hour delivery that is not already included on this sheet. Several coded comments are provided on the back of this sheet to make your paperwork go faster.

Field Information

Zanjero Name:________________

1. Date of Delivery:________________
2. Grower Name:________________
3. Canal: ________ Gate:________
4. Order Days:________________
5. Order Water:________________cfs
6. CFS Delivered (Rewrite value): ________cfs
7. What is the purpose of this irrigation (check **one**):

   _____ Crop cooling or freshening (COOL)

   _____ Germination (GERM)

   _____ Normal irrigation (IRR)

   _____ Fertilizer (FERT)

   _____ Transplanting (TRAN)

   _____ Pipe skidding (SKID)

   _____ Flood, leach, or bed prep (FLD)

   _____ Other (specify):________________

8. Finish Head: ____ Yes ____ No
9. Crop Code:________________
10. Irrigation Method (check **one**):

    _____ Flat (F)

    _____ Row (R)

    _____ Sprinkler(S)

    _____ Drip (D)

    _____ Gated Pipe (G)

11. Delivery start time:________________
12. Time water was cut from the lateral heading:________________
13. Delivery end time:________________
14. Zanjero Comments:________________

____

____

Table 1
District-Wide Cropping Patterns for 12-Hour Deliveries
Data from 10/93 through 9/94
Crops Listed in Order from Most Frequent to Least Frequently Reported

No.	Crop	Count	Percent of Total	Cummulative Percentage
1	ALFALFA	2651	13.86	13.86
2	LETTUCE	1673	8.75	22.61
3	SUDAN GRASS	1266	6.62	29.23
4	CARROTS	1235	6.46	35.68
5	ONIONS	1215	6.35	42.04
6	WATERMELONS	844	4.41	46.45
7	ROW ALFALFA	841	4.40	50.85
8	CANTALOUPES, SPRING	644	3.37	54.21
9	WHEAT	589	3.08	57.29
10	BERMUDA GRASS	584	3.05	60.35
11	VEGETABLES, MIXED	555	2.90	63.25
12	FLOODING	521	2.72	65.97
13	BROCCOLI	511	2.67	68.64
14	SUGAR BEETS	475	2.48	71.13
15	ASPARAGUS	456	2.38	73.51
16	ONIONS (SEED)	426	2.23	75.74
17	BERMUDA GRASS (SEED)	383	2.00	77.74
18	CAULIFLOWER	382	2.00	79.74
19	PASTURE, PERMANENT	378	1.98	81.72
20	PEPPERS, BELL	375	1.96	83.68
21	TOMATOES, SPRING	337	1.76	85.44
22	EAR CORN	266	1.39	86.83
23	POTATOES	197	1.03	87.86
24	CABBAGE	182	0.95	88.81
25	LETTUCE, ROMAINE	178	0.93	89.74
26	RYE GRASS	174	0.91	90.65
	75 Other Crops	1788	9.35	100.00
	Total	19126	100.00	n/a

Table 2
Comparison of 1-in-10 to District-Wide 12-Hour Delivery Database Counts

Parameter	Method															Total		
	Drip			Flat			Row & Gated			Sprinkler			Unspecified					
	1-in-10	District	%	1-in-10	District	%	1-in-10	District	%	1-in-10	District	%	1-in-10	District	%	1-in-10	District	%
Season																		
Jan - March	25	447	5.6	86	1227	7.0	233	2797	8.3	79	949	8.3	4	26	15.4	427	5446	7.8
Apr - Jun	121	1286	9.4	198	2197	9.0	175	1979	8.8	14	186	7.5	9	40	22.5	517	5688	9.1
Jul - Sep	5	68	7.4	192	2156	8.9	59	752	7.8	56	830	6.7	12	58	20.7	324	3864	8.4
Oct - Dec	5	74	6.8	68	575	11.8	77	797	9.7	237	2667	8.9	1	15	6.7	388	4128	9.4
Total	156	1875	8.3	544	6155	8.8	544	6325	8.6	386	4632	8.3	26	139	18.7	1656	19126	8.7
Division																		
Brawley	18	334	5.4	73	887	8.2	89	859	10.4	63	415	15.2	5	7	71.4	248	2502	9.9
Calipatria	23	201	11.4	40	521	7.7	71	1024	6.9	39	500	7.8	1	7	14.3	174	2253	7.7
Holtville	89	775	11.5	132	1204	11.0	154	1425	10.8	123	1547	8.0	2	2	100.0	500	4953	10.1
Southwest	7	198	3.5	216	2549	8.5	110	1425	7.7	50	752	6.6	16	119	13.4	399	5043	7.9
Westmorland	19	367	5.2	83	994	8.4	120	1592	7.5	111	1418	7.8	2	4	50.0	335	4375	7.7
Total	156	1875	8.3	544	6155	8.8	544	6325	8.6	386	4632	8.3	26	139	18.7	1656	19126	8.7
Percent of Total	9.4	9.8	n/a	32.9	32.2	n/a	32.9	33.1	n/a	23.3	24.2	n/a	1.6	0.7	n/a	100.0	100.0	n/a

The procedures used for estimating the water conservation savings associated with 12-HDs were developed by analyzing the data gathered through the 1:10 Grower responses and the Zanjero Information sheets. The analysis was tempered by the information gained from interviews with 20 growers who utilized 12-HDs. The original analysis was then independently revisited and an additional 7 growers were interviewed to focus on areas in the original analysis and interviews that needed further clarification and possible modification.

Two basic assumptions implied in the procedure used to estimate the net on-farm conservation savings for each 12-HD event, (v_c), are: 1) only 12-HDs for agricultural irrigation are considered; and 2) each 12-HD would have had (or replaces) a corresponding 24-hour delivery, 24-HD. The procedure used to estimate the **average (v_c)** values from the information contained in the 1:10 Grower Database involves six steps:

1. Classifying the 24-HD responses;
2. Applying a set of screening rules;
3. Adding a small amount of "buffer" water to 24-HD responses that are "Half" of the 12-hour order;
4. Estimating the probable effectively used portion, v_{EU}, of the excess water that would have been delivered to fill the "corresponding 24-HD" that the 12-HD was assumed to have replaced;
5. Computing the net on-farm water savings for each individual 12-HD event, $(v_c) = (v_{24} - v_{12} - v_{EU})$; and
6. Developing weighed averages by summing the individual (v_c) values for each 12-HD event and dividing by the number of like events.

Order Classification Equations

Orders were separated into classes and grouped into clusters in accordance with the flow rate in cubic feet per second (cfs) the growers ordered for each 12-HD, and their responses to the interview question "If 12-hour deliveries were not available, what would you have ordered for 24 hours?" (see Item 17 on Form 1). This was done to group and cluster the 12-HD orders in accordance with the respective 24-HD that would have been ordered if 12-HDs were not available. **The various order classes represent the sizes of the 24-HDs that were replaced compared to the sizes of the 12-HDs that replaced them.**

The main 12-HD order classes were: **Half or "H Class" orders** when the growers said their 12-HD replaced a 24-HD order that would have been ***exactly half*** of what they ordered for 12 hours; **half or "h Class" orders** when the 12-HDs were ***a little more than half*** of the 24-HDs they replaced; **Same or "S Class" orders** when the 12-HDs replaced 24-HDs that would have been ***exactly the same***; and **Minimum or "M Class" orders** that fall ***between "h and S Class" orders***. Too Low or ***"L Class" orders*** are 12-HDs that are more than double the estimated 24-HD flow rates the growers said they replaced, thus they are ***smaller than "H Class" orders, but treated as "H Class" orders***.

This grouping was considered necessary for dealing with buffers and estimating the effectively utilized portion of excess water that would have occurred with the replaced 24-HD deliveries prior to the 12-HD Program. A small amount of additional or "buffer" water was added to "H Class" orders according to the procedures discussed in the following sections. Furthermore, the order classes were grouped into an "H Cluster" made up of "H and h Class" orders and a "S Cluster made up of "M and S Class" orders. This was done so the effective utilization of the greater amount of excess water that would have occurred (prior to the 12-HD Program) as a result of having "M or S Class" orders as compared to "H or h Class" orders could be treated differently.

Another reason the 12-HDs were divided into classes was for analytical purposes. For example, comparing the numbers of "H and h Class" orders used for different purposes provided a basis for deciding on the size of buffer to add to the "H Class" orders. Studying the minimum or "M Class" orders provides insight into the minimum flow rates required for certain site conditions.

Screening Rules

Screening rules were applied during the process of computing the net on-farm conservation for each 12-HD event, (v_c). The purpose of these rules is to provide a standard system for interpreting the 1:10 Grower Database and utilizing the data to compute the (v_c) values. Seven screening rules were used to either remove events where the grower replies were inadequate or to assign values to the 12-HD and corresponding 24-HD orders in a systematic manner based on the growers' replies. Section II of the Main Report includes each of the screening rules and the rational for them. Examples of the screening rules are:

1. Remove events from the 1:10 Grower Database where no numeric or verbal value ("Half" or "Same") is given for the corresponding 24-HD order, ie., no response is given for the question "If 12-HDs were not available, what would you have ordered for 24 hours?"

   Rational: Without a value for the corresponding 24-HD there is no basis for a savings computation.

2. If a numeric value is not given for the corresponding 24-HD, then whenever the grower reported "Half" let:

   24-HD order = (12-HD order)/2

   and whenever the grower reported "Same" let:

   24-HD order = 12-HD order

   Rationale: The interviewers were instructed to check either "Half" or "Same" in place of providing numeric answers when growers said that their equivalent 24-hour order would have been either "Half" of or the "Same" as their 12-hour order.

Buffer Rules

As mentioned above, some of the 1:10 growers queried said they would have only ordered half as much water for a 24-HD if 12-HDs were not available. This was in part because they and the Order Clerks were given the option to either specify the corresponding 24-HD in cfs or say or record "Half".

When they specified half of the 12-HD flow rate (cfs) for the 24-HD order it was assumed that a small quantity of water would/should normally have been added to about half of the orders as a buffer to provide a margin of safety in case the delivered flow rate was a little less than the ordered flow rate. In the case of pressurized systems a **flow** buffer is often desired to assure that there is sufficient flow so the pump does not run short of water and loose prime. In the case of surface systems a **time** buffer is sometimes considered necessary to reduce the risk of the 24-HD flow rate not being sufficient to complete the irrigation within the 24-hour normal shut-off time. Typically, zanjeros allow up to 2 hours of extra time, ie. up to 26 hours total, but for most "H Class" surface irrigation orders a small buffer is still very useful.

From an inspection of the many "h Class" orders for which the growers included a buffer, it was deduced that the minimum appropriate buffer should be an additional 0.25 to 0.5 cfs for either pressurized or surface irrigation systems. From the grower interviews it was concluded that about two-thirds of the "H Class" orders would have been buffered. Thus it was decided it would be reasonable to add a 0.25 cfs buffer to all "H Class" orders except for surface systems when $t < 10$ hours. The logic used for eliminating the buffer for surface systems when $t < 10$ hr is that if the irrigation is finished in less than 10 hr, the irrigator would have probably known a buffer was not needed.

Effective Utilization (EU)

It was assumed that a portion of the estimated gross on-farm conservation from a given 12-HD, ($v_{24} - v_{12}$), may have been effectively used. To account for this, Effective Utilization (EU) percentages were developed for each type of 12-HD order and the gross on-farm conservation savings were reduced by multiplying them by (1.00 - EU/100) to obtain the net savings. The EU percentage was developed from the answers given to the following two part question (see Item 18 on Form 1):

Part 1: "If 12-HDs were not available, with the flow rate you indicated you would have ordered for 24 hours do you think you would end up with too much water for this irrigation?"

Part 2: "If yes, where would the excess water have gone ? (Growers were given the following choice of destinations: same field, SF; directly to the drain, D; another field, same gate, SG; different gate, DG; back to canal, C; or other.)"

To analyze the responses to this two part question, the 1:10 Grower Database was separated into two clusters as mentioned above (each representing approximately half of the sample): the "H Cluster" ("H and h Class"); and the "S Cluster" ("M and S Class") orders. The responses for only 351 or about 20 percent of the total indicated that there would not have been excess water. A total of 646 of the responses (39 percent) indicated that there would have been excess water, and that it would have been returned to the canal. A total of 385 of the responses (23 percent) indicated that the excess water would have been sent directly to the drain. Other possible responses did not represent large portions of the sample (see Table 3).

The judgments of the growers interviewed as well as those of IID field and management personnel at both the division and district levels were integrated in the process of assigning the EU percentage for the responses to the above two part question.

For Part 1 "Yes" answers. The EU percentages assumed for the various possible destinations of the 24-hour excesses (see Table 4) and the logic underlying each of them is:

- Destination Drain (D);
  EU = 0% because drainwater can not be effectively used (see column B in Table 4).

- Destination Different gate (DG);
  EU = 50% because of canal losses, and the indication from the CVC's grower interviews that the efforts to utilize the moved water often required applying unplanned irrigations on "standby" fields or irrigating some fields prematurely (see column B in Table 4).

- Destination Same field (SF);
  EU = 10% because growers indicated in the CVC interviews that irrigators would often "re-irrigated the same lands" or essentially over-irrigated with the excess water. This type of over-irrigation is assumed to result primarily in increased tile drainage and not have significant agronomic benefits (see column B in Table 4).

- Destination Different field, same gate (SG);
  EU = 50% for reasons similar to those given for the DG category (see column B in Table 4).

- Destination Back to canal (C);
  average EU = 5% for "H Cluster" orders and 7% for "S Cluster" orders (see column F in Table 4). These averages were developed as follows:

  During the CVC grower interviews many growers indicated that prior to the advent of the 12-HD Program canal returns were not common. Thus it was concluded that the answers indicating © were not a valid representation of what would have been possible without the 12-HD program. In view of this the following basis was used to obtain the EU value: 1) It was assumed that on average, 25% of the cases with © responses would have remained and been used on farm, with an EU similar to the weighted average EU for the respective (D), (DG), (SF), and (SG) designations; and 2) An EU of 5% was assumed for the remaining 75% of the © responses (see columns C, D, and E in Table 4).

For Part 1 "No" answers. An EU = 50% was assumed for the "S Class" orders, ie., where the grower indicated that the corresponding 24-HD order would have been the same as the 12-HD order but there would have been "no excess" water (see column B in Table 4). This was done because about half of them were thought to represent 12-HDs that did not result in excess water when compared to 24-HDs (such as two consecutive 12-HDs); and the other half did result in excess water. Thus it was assumed that about half of the growers did not give accurate answers; either because they misunderstood the question, took the question out of context, or did not put sufficient thought into their answer. Another possibility is that when the grower said there would be no savings, the planned destination for the unneeded water was (SG) or (DG), which in either case would have an EU = 50%.

The weighted average EU percentage (excluding the "S Class"/"No" sub-sample) for both clusters was assumed for the remaining counts with "no excess" answers. That is EU = 6% for the "H and h Class" orders and 9% for the "M Class" (see column G in Table 4).

Table 3

Profile of 1-in-10 Orders by Method, Order Class and Destination of 24-Hour Excess

Answers to Question 18			Orders by Method											
Part 1 (Would 24-HD result in excess water?)	Part 2 (Destination of excess)		Unspecified		Drip		Flat		Row		Sprinkler		Total	
	Code	Description	Count	Ave. (cfs)	Count	Ave. (cfs)	Count	Ave. (cfs)	Count	Ave. (cfs)	Count	Ave. (cfs)	Count	Ave. (cfs)
For "H Cluster" Orders														
Yes	D	Drain	7	5.14	7	2.86	68	5.69	64	5.05	19	3.79	165	5.08
	DG	Different gate	0	---	0	---	6	6.67	0	---	4	4.88	10	5.95
	SF	Same field	1	3.00	0	---	16	5.25	11	4.95	6	3.92	34	4.85
	SG	Different field, same gate	0	---	0	---	8	5.44	3	5.33	1	5.00	12	5.38
	C	Canal	4	5.38	5	3.10	86	5.66	93	4.31	59	3.90	247	4.67
		Unspecified	0	---	0	---	19	5.47	6	4.50	4	3.63	29	5.02
Other		All answers	0	---	0	---	6	4.83	0	---	4	4.63	10	4.75
No		All answers	4	4.75	4	3.50	109	5.83	91	4.86	39	4.24	247	5.17
Subtotal / Weighted Average			16	4.97	16	3.09	318	5.69	268	4.71	136	4.03	754	4.97
For "S Cluster" Orders														
Yes	D	Drain	3	3.00	26	2.33	46	4.38	82	4.02	63	3.29	220	3.68
	DG	Different gate	0	---	1	1.50	13	5.73	11	4.09	14	4.14	39	4.59
	SF	Same field	1	1.50	0	---	25	5.48	28	4.63	16	3.50	70	4.63
	SG	Different field, same gate	0	---	4	3.00	6	4.58	12	4.46	10	4.40	32	4.28
	C	Canal	2	6.50	94	1.78	95	4.66	102	3.53	106	3.14	399	3.30
		Unspecified	0	---	0	---	14	4.96	8	4.69	5	4.50	27	4.80
Other		All answers	0	---	1	1.50	4	3.25	2	4.50	4	2.13	11	2.91
No "M Class"		All answers	0	---	0	---	10	6.25	7	4.86	2	5.25	19	5.63
"S Class"		All answers	4	3.38	14	2.00	13	3.92	24	3.23	30	3.45	85	3.22
Subtotal / Weighted Average			10	3.70	140	1.93	226	4.77	276	3.90	250	3.37	902	3.67
Total			26	4.48	156	2.05	544	5.31	544	4.30	386	3.60	1,656	4.26

For Unspecified and "Other" answers and when t is less than 10.5 hours. For the unspecified and "other" answers the weighted average EU percentage was used for both clusters. That is EU = 6% for the "H Cluster" orders; and 9% for the "S Cluster" orders (see Column H in Table 4).

For "H Cluster" orders when t is greater than 10.5 hours. For the "H Cluster" orders it was assumed that no effective utilization would occur (EU = 0) for durations greater than 10.5 hours (see column H' in Table 4). This is because the only water that could be beneficially used is water from early shut-offs. Also in these cases it was assumed that the equivalent 24-HD would have lasted for approximately 24 hours (would not be shut off early). Therefore, any excess water would be buffer water that can not be "effectively utilized" because it would not be dependable or only occur for a relatively short duration.

Weighted averages and EU values used. The 12-HD 1:10 Grower Database includes 1656 entries. Columns H and H' in Table 4 show the EU percentages used for the numbers of counts or events of the various types indicated in column A. The global weighted average 12-HD order = 4.26 cfs and the global volume weighted average EU = 12% for the 1:10 Grower Database (see Tables 3 and 4).

Estimating Conservation Savings

The general equation for estimating the net on-farm conservation savings associated with each 12-HD event, (v_c), is:

A. For $(t_{24} \times Q_{24})$ greater than $(t \times Q_{12})$;

$$(v_c) = (1/12.1)(1 - \%EU/100)[(t_{24} \times Q_{24}) - (t \times Q_{12})]$$

B. For $t_{24} \times Q_{24}$ less than or equal to $(t \times Q_{12})$;

$$(v_c) = 0, \text{ when t less than 14.5 hours}$$

and

$$(v_c) = (1/12.1)(1 - \%EU/100)[(24 \times Q_{12}) - (t \times Q_{12})], \text{ when t greater than or equal to 14.5 hours}$$

in which:

(v_c)	=	estimated volume of water conserved for each 12-HD event, AF
EU	=	estimate of excess 24-HD water that would have been effectively utilized, %
Q_{24}	=	estimate of probable 24-HD rate of flow if 12-HD was unavailable, cfs
t	=	actual duration of each 12-HD irrigation event, hr
t_{24}	=	24 for all "M and S Class" orders, hr 24 for "H and h Class" orders for $t \leq 12$ hr, hr 2 x t for "H and h Class" orders for $t \geq 12$ hr, hr
Q_{12}	=	rate of flow delivered, Q_d, to fill the 12-HD order, O_{12}, as estimated by the zanjero/night-patrolman, except where no Q_d is given or Q_d deviates more than $\pm$ 25% from O_{12}, in which case $Q_{12} = O_{12}$, cfs

Table 4
Computation of Effective Utilization (EU) Fractions

Answers to Question 18 Part 1 (Would 24-HD result in excess water?)	Part 2 (Destination of excess) Code	Part 2 (Destination of excess) Description	Count of 1-in-10 Data (A)	EU* (B)	Wt. Ave. EU (C)	EU* (D)	Distrib. of C* (E)	Wt. Ave. EU (F)	Wt. Ave. EU for Class (G)	Resulting EU t <= 10.5 hr (H)	Resulting EU t > 10.5 hr (H')	Desti-nation Code
For "H Cluster" Orders												
Yes	D	Drain	165	0%						0%	0%	D
	DG	Different gate	10	50%						50%	0%	DG
	SF	Same field	34	10%	7%					10%	0%	SF
	SG	Different field, same gate	12	50%					6%	50%	0%	SG
	C	Kept on-farm	247			7%	25%			5%	0%	C
		Canal				5%	75%	5%				
		Unspecified	29									
Other		All answers	10							6%	0%	U
No		All answers	247									
For "S Cluster" Orders												
Yes	D	Drain	220	0%						0%		D
	DG	Different gate	39	50%						50%		DG
	SF	Same field	70	10%	12%					10%		SF
	SG	Different field, same gate	32	50%					9%	50%		SG
	C	Kept on-farm	399			12%	25%			7%		C
		Canal				5%	75%	7%				
		Unspecified	27									
Other		All answers	11							9%		U
No "M Class"		All answers	19									
"S Class"		All answers	85	50%						50%		N/S
Total			1,656	**Global Volume Weighted Average**						12%		

* Assumed values based on CVC interviews with selected growers.

The entire 12-HD database generated from the 1:10 grower queries was analyzed to estimate the net on-farm conservation savings associated with each 12-HD event, (v_c). The results of this analysis are summarized in Table 5. The results for each method of irrigation and order class along with the respective order counts, durations, and sizes and the respective savings are summarized in the top five windows. Average savings for each of the irrigation methods were used in developing an inference model for estimating the conservation savings for the district-wide use of 12-HDs. The averages for each order class and the overall averages for the entire 1:10 Grower Database are summarized in the bottom window.

In addition to providing data for the inference model the table provides a profile of 12-HD use, order sizes, and savings. For example, it is interesting to note that: the average duration is almost 12 hours; the average "S Cluster" order is only about 3.5 cfs while the average "H Cluster" order is about 5.0 cfs; however, the average savings from "H Cluster" orders is about 1 AF while it is nearly 3 AF for "S Cluster" orders.

Sensitivity to Major Assumptions

A number of assumptions associated with the different types of 12-HDs were made in developing the estimates for the conservation savings from the 1:10 Grower Database. The various assumptions or conditions are associated with the Screening Rules, Buffer Rules, and Effective Utilization Criteria. Each of the assumed conditions was tested by analyzing the effect (as a percentage increase or decrease) that using alternate values (or tested conditions) would have on the Total Net On-Farm Conservation Savings computed for the entire 1:10 Grower Database (see Table 6).

The right hand column in Table 6 shows the effect (as a + or - percentage) on the Total Net On-Farm Savings based on the average savings of all events in the 1:10 Grower Database. From an inspection of these it is evident that the Total is not very sensitive to any single assumption and it has been concluded that the assumed conditions are reasonable. Furthermore, it was decided that it would be best to use the assumed conditions because they do provide a means for keeping the 1:10 Grower Database as large as possible (with 1656 events) to develop the inference analysis for making Total Net On-Farm Water Conservation Savings projections in future years.

The meaning of the flow rate and volume terms (or symbols) used in Table 6 are as follows:

Qd is the 12-HD flow rate delivered in cfs;
O12 is the 12-HD flow rate ordered in cfs;
Q12 is the 12-HD flow rate in cfs used in calculating V12 the volume of water delivered in AF;
O24 is the 24-HD flow rate in cfs that the grower said he would have ordered if 12-HDs were not available;
V24 is the volume of water in AF that would have been delivered by the 24-HD order that was replaced by the 12-HD order; and
Vc is the net on-farm volume of water in AF conserved by each 12-HD event.

Table 5
Profile of 1-in-10 Database by Method and Order Class

Order Class	Drip Count	Drip Average Duration (hours)	Drip Average Order (cfs)	Drip Average Savings (AF)	Flat Count	Flat Average Duration (hours)	Flat Average Order (cfs)	Flat Average Savings (AF)	Row Count	Row Average Duration (hours)	Row Average Order (cfs)	Row Average Savings (AF)
L	0	---	---	---	25	11.0	6.06	1.44	15	12.3	4.87	1.34
H	9	11.8	3.56	0.79	190	11.7	5.44	0.97	156	11.7	4.74	0.85
h	7	12.1	2.50	1.04	103	12.0	6.06	1.43	97	11.9	4.65	1.28
M	2	13.2	2.50	1.16	61	11.5	5.91	2.62	54	12.2	5.37	2.47
S	138	11.0	1.92	1.82	165	12.1	4.35	3.73	222	11.6	3.54	3.14
Total / Ave.	156	11.1	2.05	1.72	544	11.8	5.31	2.10	544	11.8	4.30	2.03

. . .

Table 6 (continued)

Order Class	Sprinkler Count	Sprinkler Average Duration (hours)	Sprinkler Average Order (cfs)	Sprinkler Average Savings (AF)	Unspecified Count	Unspecified Average Duration (hours)	Unspecified Average Order (cfs)	Unspecified Average Savings (AF)
L	10	10.0	4.25	1.55	0	---	---	---
H	65	10.9	4.11	0.82	10	10.2	5.15	1.13
h	61	11.3	3.92	1.06	6	12.2	4.67	0.87
M	18	11.1	4.78	2.50	1	5.0	7.00	6.55
S	232	11.5	3.26	2.76	9	10.7	3.33	2.94
Total / Ave.	386	11.3	3.60	2.12	26	10.6	4.48	1.90

. . .

Table 6 (continued)

Order Class	Subtotal Count	Subtotal Average Duration (hours)	Subtotal Average Order (cfs)	Subtotal Average Savings (AF)	Percent of Count	Absolute Savings (AF)	Percent of Absolute Savings (by Class)	Percent of Absolute Savings (by Cluster)	Order Cluster
L	50	11.2	5.34	1.43	3%	71	2%	24%	H
H	430	11.6	4.94	0.90	26%	388	11%		
h	274	11.8	4.96	1.27	17%	348	10%		
M	136	11.7	5.50	2.55	8%	347	10%	76%	S
S	766	11.6	3.34	2.91	46%	2,230	66%		
Total / Ave.	1,656	11.6	4.26	2.04	100%	3,384	100%	100%	Total/Ave

Table 6
Sensitivity to Major Assumptions

Item No.	Description	% of Database	Assumed Condition	Tested Condition	Effect on Net On-Farm Conservation*
1	"L Class" orders	3%	Treat as "H Class"	Omit	0.9%
2a	When Qd is not given	4%	Q12 = O12, t = end time - start time	Omit	0.3%
b	When $\lvert Qd-O12\rvert/O12 > 0.25$	6%	Q12 = O12, t = end time - start time	Omit	0.5%
				Q12 = Qd, t = end time - start time	0.9%
c	When Qd is not given or $\lvert Qd-O12\rvert/O12 > 0.25$	10%	Q12 = O12, t = end time - start time	Omit	0.8%
				Q12 = O12, t = 12 hours	-0.6%
3	When V24 < V12	5%	Q24 = Q12 but Vc=0 if t < 14.5 hours	Omit	-0.1%
				Q24 = Q12 but Vc=0 if t < 13.5 hours	2.6%
4	When start or end time not given	5%	Assume t = 12 hours	Omit	0.2%
5a	Add buffer to all "H Class" orders except surface irrigation when t < 10 hours	4%	Buffer = 0.25 cfs	Buffer = 0.125 cfs	-2.5%
				Buffer = 0.375 cfs	2.7%
b	For "H Class" surface irrigation orders	25%	Add 0.25 cfs buffer when t >= 10 hour	Add 0.25 cfs buffer when t >= 9 hours	0.4%
				Add 0.25 cfs buffer when t >= 11 hour	-0.4%
6	EU = 0 for "L, H and h Class" Orders	9%	When t > 10.5 hours	When t > 10 hours	0.1%
				When t > 11 hours	-0.1%
7	EU of "DG" events	3%	50.0%	25.0%	1.8%
				75.0%	-1.8%
8	EU of "SG" events	3%	50.0%	25.0%	1.4%
				75.0%	-1.4%
7 & 8	EU of "DG" and "SG" events combined	6%	50.0%	25.0%	3.2%
				75.0%	-3.2%
9	EU of "SF" events	6%	10.0%	5.0%	0.6%
				15.0%	-0.6%
10	Distribution of "C" answers and	39%	C:25%/75%; EU:5%	C:0%/100%; EU: 0%	3.2%
				C:25%/75%; EU: 0%	1.8%
				C:25%/75%; EU: 10%	-1.8%
				C:50%/50%; EU: 10%	-2.0%
11	EU of "No/Same" events	5%	50.0%	25.0%	2.0%
				75.0%	-2.0%

* Based on average On-Farm Water Conservation Savings for the 1:10 Grower Database.

Screening and buffer rule assumptions. The first 5 Items in Table 6 involve the screening and buffer rule assumptions. The logic for each of the assumed conditions is presented under "Screening Rules" in Section II of the Main Report. Following is a listing of each Assumed Condition and the Tested Conditions with the logic underlying them:

1. The **assumed condition** is that "L Class" orders be treated as "H Class" orders; and the **tested condition** is to remove them from the database because they are illogical events. The impact, for example, of doing this would be to increase the Total Net On-Farm Conservation Savings by 0.9%.

2a. The **assumed condition** is that when Qd is not given, then Q12 = O12 and t is the actual duration of irrigation (the ending time - the starting time); and the **tested condition** is to remove these events from the database because Qd is unknown.

b. The **assumed condition** is that when the absolute value of [Qd - O12]/O12 is greater than 0.25, then Q12 = O12 and t is the actual duration; and the **tested conditions** are to either remove these events from the database because there is too much difference between O12 and Qd, or to let Q12 = Qd and t be the actual duration because that is what took place.

c. The **assumed condition** is that when Q12 is not given or the absolute value of [Qd - O12]/O12 is greater than 0.25, then Q12 = O12 and t is the actual duration; and the **tested conditions** are to either remove these events from the database because there is too much difference between O12 and Qd, or to let Q12 = O12 and t = 12 hours because that was the actual intent when the order was made and is the basis under which O_{24} was estimated and thus V24 is computed.

3. The **assumed condition** is that when V24 is less than V12 (which only occurs for "L, H, or h Class" orders when the duration, t is 13 or more hours) then Q12 = O24 but Vc = 0 if t is less than 14.5 hours; and the **tested conditions** are either to remove these events from the database because these 12-HDs would produce impractical negative savings values, or to let Vc = 0 if t is less than 13.5 hours because for the "H cluster" of orders that would be equivalent to having the replaced 24-HD for 2 x 13.5 = 27 hours and a 3-hour overrun is as long as would be allowed.

4. The **assumed condition** is that when the start or end time is not given then t = 12 hours; and the **tested condition** is to remove these events from the database because the actual duration cannot be determined.

5a. The **assumed condition** is that 0.25 cfs be added to all "H Class" orders except surface irrigation orders when t is less than 10 hours; and the **tested conditions** are to add either 0.125 or 0.375 cfs instead to test the sensitivity to the size of buffer used.

b. The **assumed condition** is that 0.25 cfs be added to all "H Class" orders except surface irrigation orders when t is less than 10 hours, and the **tested conditions** are to add the 0.25 cfs buffer as above but replace the "10 hour limit" with 9 or 11 hours as the t below which a buffer is not added to the surface irrigation "H Class" orders to test the sensitivity of the duration at which the buffer is applied to "H Class" surface irrigation events.

EU criteria assumptions. The development of the EU percentages is based on the assumptions presented earlier. The sensitivity analysis presented for Items 6 through 11 in Table 6 provides a means for evaluating how changing each of the individual EU percentages by a reasonable amount (either up or down) would affect the Total Net On-Farm Water Conservation Savings estimates. In view of the logic presented under the sub-heading *Effective Utilization (EU)* presented earlier for the **assumed conditions**, the logic underlying the **tested conditions** should need no further explanation.

INSTITUTIONALIZING ANNUAL NET ON-FARM CONSERVATION ESTIMATES

Section III of the Main Report lays out the strategy for computing the Annual Net On-Farm Water Conservation Savings for the 12-HD Program. This is the first step in computing the annual estimate for the Net Water Conservation Savings that has been made possible by the added flexibility afforded by the 12-HD Program. Subsequently the consequential operational losses (additional lateral and main canal spillage) resulting from the extra water manipulations associated with terminating the 12-HDs must be subtracted from the net on-farm savings. In addition, the rules governing the use of 12-HDs must be held constant or rule changes documented and appropriate modifications made to the verification procedure. The procedure for "institutionalizing the computation of the net on-farm conservation estimates" and a framework for dealing with "rule changes" are discussed below.

The strategies and procedures used for estimating the **consequential operational losses** are presented in Part II of the 12-HD Verification Summary Report. Part II also contains a section covering the allocation of a portion of the net conservation savings from the 12-HD Program, Project 9, to System Automation, Project 15, because without the additional automation the operational spillage would have been considerably greater.

Net On-Farm Conservation

The procedure developed for estimating the 12-HD gross on-farm conservation savings, $(V_c)_{94}$, for the Projected 1995 Water Conservation Savings was directly based on the 1993-94 (water year 1994) data. With the grower query responses for a random sample of roughly 10 percent of the population of 12-HDs, the 1994 V_c estimate, $(V_c)_{94}$, could be based on the estimated average savings per 12-HD, $(v_c)_{AV}$, calculated from the 1:10 Grower Database. The total District wide savings, $(V_c)_{94}$, is equal to $(v_c)_{AV}$ times the total number of 12-HD throughout the District during the 1994 water year, n_{94}, when the 1:10 Grower Database was being collected and developed ie:

$$(V_c)_{94} = n_{94} \bullet (v_c)_{AV}$$

The conservation estimates for each future year could be made by simply determining the number of 12-HDs for the year in question and the $(v_c)_{AV}$ that is based on the 1:10 Grower Database (from the 1994 water year). Then using the above equation to estimate the V_c. However, this would not take into account changes in the usage of 12-HDs.

Therefore, an equation relating the (v_c) values determined from the 1:10 Grower Database to how the individual 12-HDs was developed to provide more accurate future estimates of V_c. It was found that the method of irrigation is the most significant factor in estimating the water conservation associated with each 12-HD event. In view of this the initial effort at developing the equation was to determine the following for the 1:10 Grower Database (see Table 5):

$(v_c)_D$ = average savings per 12-HD for **drip** irrigation, AF
$(v_c)_S$ = average savings per 12-HD for **sprinkler** irrigation, AF
$(v_c)_F$ = average savings per 12-HD for **flat** irrigation, AF
$(v_c)_R$ = average savings per 12-HD for **row** irrigation, AF

Using this breakdown, the estimated gross on-farm water conservation savings for the 1994 water year was:

$$(V_c)_{94} = (n_{94} \bullet v_c)_D + (n_{94} \bullet v_c)_S + (n_{94} \bullet v_c)_F + (n_{94} \bullet v_c)_R$$

In which the n_{94} values in the parentheses are the respective numbers 12-HDs associated with the drip, sprinkler, flat, and row irrigation methods.

Improved inference model for estimating net on-farm conservation. To increase the validity of future conservation estimates under possible changing conditions, the CVC investigated other inference relationships. A total of 17 subgroups based on irrigation method, crop, and season were identified. An analysis of variance showed that the 17 subgroups could be combined into a minimum of three groups with significantly different means. However, rather than collapse the grouping to the minimum of three, it was decided to maintain a grouping convention that observed the different irrigation methods. This approach yielded the following six subgroups and average net on-farm savings per 12-HD for each of them:

$(v_c)_{F1}$ = 2.746 AF for flat (border irrigated) alfalfa from May through August
$(v_c)_{F2}$ = 1.817 AF for all other flat irrigated crops and seasons
$(v_c)_{R1}$ = 2.133 AF for all row irrigated crops except vegetables during January-August
$(v_c)_{R2}$ = 1.645 AF for row irrigated vegetables during January-August
$(v_c)_S$ = 2.122 AF for all sprinkler irrigations
$(v_c)_D$ = 1.718 AF for all drip irrigations

For future estimates of the Total Net On-Farm Water Conservation Savings associated with the 12-HD Program, these $(v_c)_{sub\text{-}group}$ values will be used as the coefficients in an equation similar to the one presented above for the 1995 Conservation Projections. Table 7 shows the data used and the development of the 1996 Projected Net On-Farm Conservation Estimate from the 1995 water year 12-HD data.

Rules Governing Use of 12-HDs

The verification procedure described in this report is valid for the types of 12-HD uses that exist under the current IID rules. The rule change of limiting the maximum delivery rate to 5 cfs during the spring and fall of the 1996 water year will affect the way farmers use 12-HDs and the associated savings. This may restrict certain uses that were more prevalent with the original 7 cfs in effect when the 1:10 Grower Database was developed, and thus influence the savings potential predicted by the equations (or inference model) presented above. For example, the existing rule limiting the maximum 12-HD delivery rate to 7 cfs provides water savings potential while discouraging 12-HD use for only labor savings. However, the lower 5 cfs limit could limit a type of 12-HD use that was more prevalent under the 7 cfs limitation.

In view of the above, the CVC suggested that is was important for verification purposes that the following be done: 1) examine the potential impacts of any proposed rule change *before* it is made; 2) document any changes that may be adopted; and 3) develop appropriate modifications to the verification procedure to cover possible changes in 12-HD use. The CVC has examined the potential impacts of the 5 cfs limitation and the 5 cfs limitation has been properly documented (to accommodate the first two criteria).

Table 7

Summary of 1996 Net On-Farm Conservation

Irrigation Method	Crops	Season	Count by Group	Unit Conservation Vc (AF/12HD)	Net Conservation (AF/Year)	Category Code
Flat	Alfalfa	May - Aug	1,362	2.746	3,740	F1
		Sep - Apr	5,371	1.817	9,760	F2
	All except alfalfa	All year				
Row	All except vegetables	All year	5,138	2.133	10,957	R2
	Vegetables	Sep - Dec				
		Jan - Aug	1,236	1.645	2,033	R1
Sprinkler	All	All year	5,311	2.122	11,272	S
Drip	All	All year	2,327	1.718	3,999	D
Subtotal			20,745	---	41,760	
Weighted Average				2.013	---	
Unspecified	Various	All year	149	2.013	300	
Total			20,894	---	42,060	

A new 1:10 Query activity to determine how many of the 4, 4.5, or 5 cfs 12-HD orders would have been placed as 5.5, 6, 6.5, or 7 cfs orders if they were still available. The CVC may modify these 12-HD Verification Procedures using this new 1:10 5 cfs Limitation Database (to satisfy the third criteria above).

INDEPENDENT VALIDATION ANALYSIS

Section IV of the Main Report provides independent backup for the conservation estimate derived from the individual irrigation event based strategy that is based grower/irrigator's responses to the 1:10 12-HD queries. For the individual event based strategy, which is depicted in the upper part of Figure 1, the "inflow" differentials (for each 12-HD as compared to the 24-HD it replaced) is estimated for each irrigation of any "field" receiving a 12-HD. Thus it is a "single event" based strategy and the total conservation savings is the sum of the estimated conservation savings from each of the 12-HD events.

Two conservation savings estimating strategies were employed for the validation analysis, an analysis of "finish heads" and an analysis of "delivery differentials". These validation techniques were based on "multiple event" strategies using "district" wide differential "inflow" information and is depicted in the lower portion of Figure 1. The order and delivery information stored in IID's AS400 computer files was used for the validation analysis. The primary data source for this analysis was the most recent version of the "CFS Files" created through a query of IID's AS400 computer. These records include district-wide irrigation events from July 1, 1986 through June 30, 1995. This data was supplemented with a minor sampling of the Zanjero Database.

In addition (to the CFS File validation analysis) a comparison was also made between the resulting savings estimate based on the (1993-4 water year) 1:10 Grower Database and a savings estimate based on the 12-Cooperating Grower Database developed during the 1992-3 water year.

Finish Head (FH) Analysis

An analysis of the CFS Files was made to separate the deliveries into six categories by annual delivery days and AF delivered for each of the past nine 12-month periods (beginning with July 1, 1986 through June 30, 1995, see Table 8). The purpose of the FH analysis was to determine how the use of FHs has been affected by the 12-HD Program. The latest tallies in Table 8 (from 1993 to 1995) indicate that about 20 percent of all 12-HDs are FHs. These have replaced almost half of the 24-HD FHs. However, the total number of FHs has hardly increased since 1989 when the 12-HD Program began.

The total number of deliveries decreased during 1990-91, when the number of 12-HDs increased the most rapidly (see Table 8). This indicates that the 12-HD Program did not induce additional irrigation events, supporting one of the basic assumptions that absent the 12-HD Program, there would have been a 24-HD for each 12-HD used.

The total number of FHs (12-HD and 24-HD FHs combined) does not change much over the study period because as 12-HD FHs increase, 24-HD FHs decrease. This indicates that 12-HD FHs have replaced approximately half of the 24-HD FHs on a one-to-one basis.

Although "stock water" events represent a significant number of district-wide deliveries, they represent very little volume. Furthermore, the total volume of FHs has not changed very much during the study period (see Table 8). However, the average FH delivery has decreased by approximately 0.64 AF/day

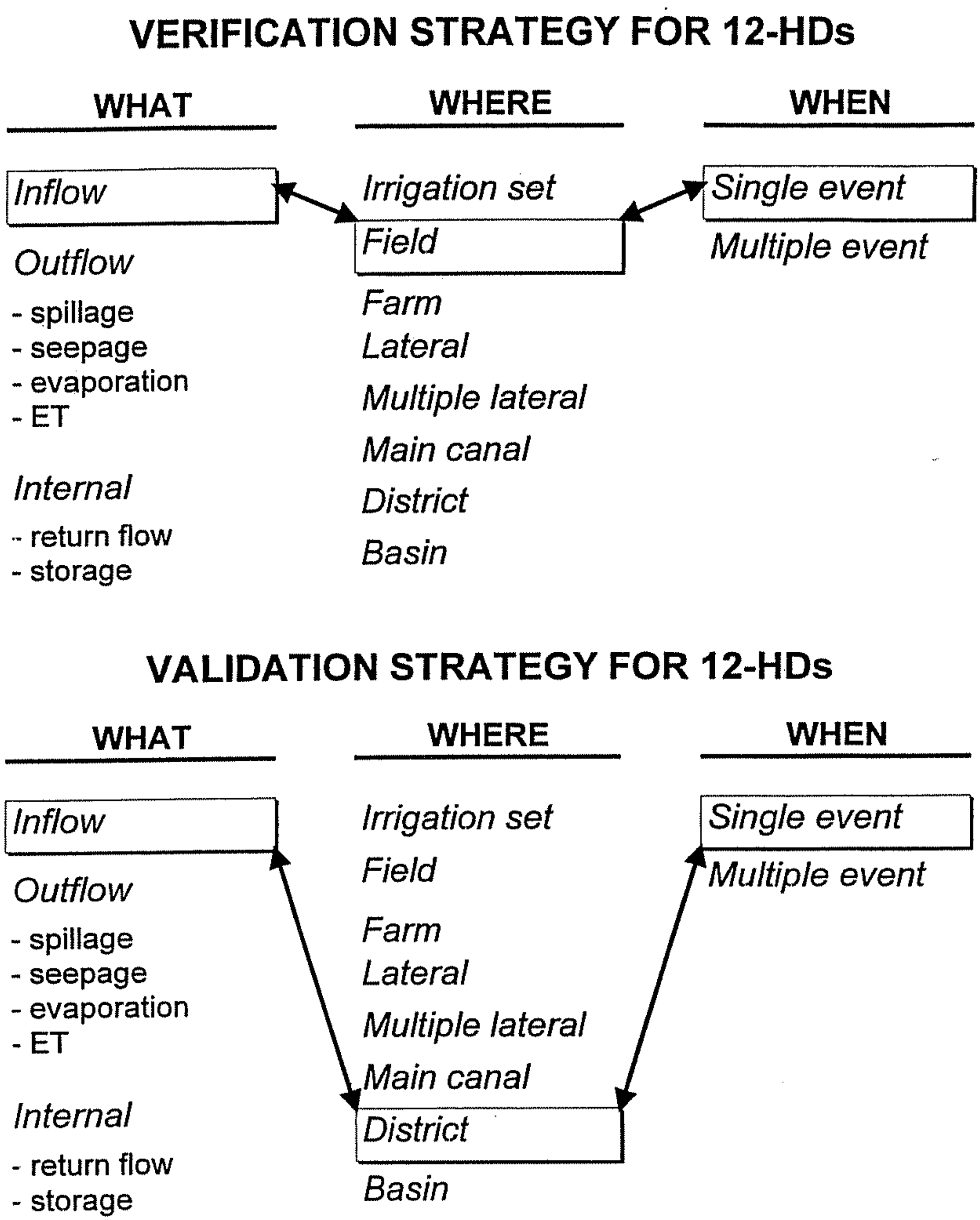

Figure 1. Comparison Between Verification and Validation Strategies for Net On-farm 12-HD Conservation Savings

Table 8
Profile of 12- and 24-HD Finish Heads and Non-Finish Head Events*

Year	Finish Heads			Not Finish Heads			All 12- and 24-Hour Events*		
(July 1 -June 30)	24HD	12HD	Subtotal	24HD	12HD	Subtotal	24HD	12HD	Total
Number of Delivery Days									
1987	8,061	0	8,061	147,193	183	147,376	155,254	183	155,437
1988	8,290	0	8,290	145,845	1	145,846	154,135	1	154,136
1989	9,305	0	9,305	168,071	0	168,071	177,376	0	177,376
1990	8,741	394	9,135	169,117	5,347	174,464	177,858	5,741	183,599
1991	6,267	2,462	8,729	159,616	13,169	172,785	165,883	15,631	181,514
1992	5,012	3,428	8,440	141,845	12,214	154,059	146,857	15,642	162,499
1993	4,552	3,615	8,167	134,465	12,787	147,252	139,017	16,402	155,419
1994	5,051	4,180	9,231	153,535	15,896	169,431	158,586	20,076	178,662
1995	5,125	4,496	9,621	154,158	17,648	171,806	159,283	22,144	181,427
Average 1990-95		3,096	8,887						
Average Irrigation Delivery (AF/Day)									
	Average	Average	Weighted Average	Average	Average	Weighted Average	Average	Average	Weighted Average
1987	11.1	N/A	11.1	14.9	4.9	14.9	14.7	4.9	14.7
1988	11.3	N/A	11.3	14.9	9.9	14.9	14.7	9.9	14.7
1989	11.2	N/A	11.2	14.9	N/A	14.9	14.7	N/A	14.7
1990	11.4	4.2	11.1	14.9	3.5	14.6	14.8	3.5	14.4
1991	12.8	6.1	10.9	15.3	4.2	14.5	15.2	4.5	14.3
1992	13.8	5.9	10.6	15.7	4.0	14.7	15.6	4.4	14.5
1993	14.3	5.3	10.3	15.5	3.9	14.5	15.5	4.2	14.3
1994	14.3	5.3	10.2	15.7	3.8	14.6	15.7	4.1	14.4
1995	14.4	5.5	10.2	15.9	3.9	14.7	15.9	4.2	14.4
Average 1987-89			11.2						
Average 1990-95			10.6						

* Stock orders are not included.

(11.20 AF/day for 1987 through 1989 less 10.56 AF/day for 1990 through 1995) even though the average 24-HD has increased over the last nine years (see Table 8).

Assuming that the characteristics of the remaining 24-HD FHs have not changed, the difference in the average quantity of water, 0.64 AF/day, delivered per FH event before and after the 12-HD Program began can be used to estimate the average savings associated with each 12-HD FH event. To do this the 0.64 AF/day is multiplied by 8,887 days (the average number of FH delivery days per year during the six post-project years) to obtain an average FH delivery difference of 5,704 AF between the pre- and post-12-HD Program periods. This delivery difference of 5,704 AF is then divided by 3,096, the average number of 12-HD FH days during the post-project period to obtain an average gross on-farm savings for each 12-HD FH. Given the average effective utilization, EU = 0 % (to drain) for the "FH" responses in the 1:10 Database, the average net on-farm savings per 12-HD FH is 1.84 AF.

This is close to the average net on-farm savings of 2.06 AF for all surface irrigation events in the 1:10 Grower Database (see Table 5). Furthermore, 12-HD FH irrigations represent almost half (43 percent) of all 12-HD surface irrigation events. **Thus the finish head analysis provides strong analytical and independent non-subjective support to the validity of the estimated on-farm conservation savings derived from the 1:10 Grower Database.**

Delivery Differential Analysis

An analysis of the CFS Files was made to separate the deliveries into three categories by annual delivery days and AF delivered for each of the past nine 12-month periods (beginning with July 1, 1986 through June 30, 1995). The three categories are: 24-HDs; 12-HDs; and combined 24-HDs and 12-HDs. The results of this query of the CFS File are presented in Table 9.

The total volume of order days (ODs) has not changed very much during the study period (see Table 8). However, the average delivery per OD has decreased by approximately 0.32 AF/day (14.712 AF/day for 1987 through 1989 less 14.393 AF/day for 1990 through 1995) even though the average 24-HD has increased over the last nine years (see Tables 8 or 9).

The average 12-HD would need to be 7.7 AF/day for the post-12-HD project average delivery per OD to be the same as for the pre-project period. This is almost twice the average 12-HD, which is an indication that farmers are not abusing 12-HDs by simply replacing their small 24-HDs with 12-HDs having twice the flow rate and only using them for half as long.

Assuming that the characteristics of the remaining 24-HDs have not changed, the difference in the average quantity of water, 0.32 AF/day, delivered per OD before and after the 12-HD Program began can be used to estimate the average annual savings associated with the 12-HD Program (or the average savings per 12-HD). To do this the 0.32 AF/day is multiplied by 173,853 days (the average number of ODs per year during the six post-project years) to obtain an average delivery difference of 55,460 AF between the pre- and post-12-HD Program periods. This delivery difference of 55,460 AF can be divided by 15,940 (the average number of 12-HDs during the post-project period) to obtain an average gross on-farm savings of approximately 3.48 AF for each 12-HD.

Table 9
12-HD Conservation Savings Based on Delivery Sizes and Numbers

June - July Water Year	24-HD Deliveries			12-HD Deliveries			Combined 24-HD and 12-HD Deliveries		
	Ave Delivery (AF/day)	Number of Order Days	Total (AF)	Ave Delivery* (AF/day)	Number of Order Days	Total (AF)	Ave Delivery (AF/day)	Number of Order Days	Total (AF)
1987	14.730	155,254	2,286,903	4.941	183	904	14.719	155,437	2,287,807
1988	14.721	154,135	2,269,014	9.918	1	10	14.721	154,136	2,269,024
1989	14.698	177,376	2,607,079	N/A	0	0	14.698	177,376	2,607,079
1990	14.770	177,858	2,626,972	3.509	5,741	20,143	14.418	183,599	2,647,115
1991	15.210	165,883	2,523,000	4.471	15,631	69,888	14.285	181,514	2,592,888
1992	15.599	146,857	2,290,842	4.450	15,642	69,605	14.526	162,499	2,360,448
1993	15.499	139,017	2,154,674	4.172	16,402	68,431	14.304	155,419	2,223,105
1994	15.696	158,586	2,489,153	4.080	20,076	81,913	14.391	178,662	2,571,066
1995	15.858	159,283	2,525,833	4.195	22,144	92,888	14.434	181,427	2,618,720
Average of 1987 - 1989							14.712	162,316	2,387,970
Average of 1990 - 1995					15,939		14.393	173,853	2,502,224
Difference							0.319		

* The average 12-HD would have to had to be 7.693 AF for no change in the overall average delivery size.

The volume weighted average (or global) effective utilization, EU = 11 % for the 1:10 Grower Database (see Table 4). Thus the average annual net on-farm savings per 12-HD based on the above analysis would be: (1 - 0.12) x 3.48 = 3.06 AF. This is considerably higher than the average net on-farm savings of 2.013 F/12-HD estimated for all irrigation events in the Zanjero Database for the 1995 water year. However, it includes the reduced farm deliveries associated with Tailwater Recovery Systems (TRS) and the additional flexibility provided for 24-hour deliveries (AdFx) since the 12-HD Program began.

If the 3.10 AF/12-HD were used in place of the 2.013, the total net on-farm conservation estimate for the *Projected 1996 Water Conservation Savings* would have been (20,894 12-HDs) x (3.06 AF/12-HD) = 63,935 AF instead of the 42,060 AF used for the 1996 estimates. The difference (63,935 - 42,060 = 21,875 AF) is about the same as the sum of the reduction in deliveries associated with the TRS and AdFx activities. **Thus the delivery day analysis provides strong analytical and independent non-subjective support indicating that the estimated on-farm conservation savings derived from the 1:10 Grower Database may be on the low or conservative side.**

Conservation Estimates from 12-Grower and 1:10 Databases

The estimated net on-farm conservation savings per 12-HD derived from the 12-Cooperating Grower Database and used in projecting the Water Conservation Savings for 1994 was 1.68 AF. This is reasonably close to the 2.04 AF computed from the 1:10 Grower Database. An analysis of the responses from the same 12 cooperating growers in the 1:10 Grower Database showed that on average their responses were similar between 1993 and 1994.

Both the 12-Cooperation Grower and the 1:10 Grower Databases provide subjective data. But, **the fact that the responses from one year to another give similar results adds to the confidence in the interview and analytical processes used to estimate the net on-farm conservation savings associated with 12-HDs.**

PART II:
CONSEQUENTIAL SPILLAGE

Quantifying the increase in lateral spillage as a consequence of the 12-HD Program is necessary for verifying the Conservation Savings associated with the it.

BACKGROUND

While the 12-HD Program generates large on-farm conservation savings, the management of the 12-hour deliveries results in additional lateral spillage compared to the normal operational spillage associated with the 24-hour deliveries they replace. This additional spillage is captured and conserved where laterals are intercepted and the potential spills are immediately available for use down steam or stored for future use.

Understanding and quantifying lateral spillage is an important aspect of conservation verification for five projects in the IID/MWD Water Conservation Program. These are the three interceptor projects, system automation, and the 12-HD Program. Therefore, it was most efficient to address lateral canal spillage as a general issue because these projects either target canal spillage for conservation or cause spillage to increase as a consequence of project operation as is the case for the 12-HD Program.

In view of the above the CVC elected to develop a separate study focused on canal spillage. The DRAFT Report, *Analysis of Canal Spillage in Imperial Irrigation District*, dated September 1997 and revised in September 1998 contains a full description of the strategies used in developing the study and essential outputs resulting from it. Consequently, it is not necessary nor would it be efficient to include the details of the work herein.

NET CONSERVATION SAVINGS

The net conservation savings associated with 12-HDs are shared by Project 9, the 12-HD Program, and Project 15, System Automation, in proportion to their relative total fixed plus operational costs. The strategy for doing this is presented in the Project 15 VSR. The Consequential Effect Elements, which are the increased canal spillages induced by the 12-HDs, must be subtracted from the Conservation Elements, which for 12-HDs is the sum of the reductions in deliveries to farm headgates to determine the net conservation savings. Thus:

Net 12-HD Conservation Savings = Sum of the Net On-Farm Savings - Increased Lateral Spillage

Part I of this VSR focused on the strategies, procedures, and computations used for determining the Sum of the On-Farm Savings associated with the 12-HDs.

INCREASED LATERAL SPILLAGE

Lateral spillage is potentially increased as a result of stating and terminating 12-HDs. It is actually lost where laterals discharge into IID drains, which in turn flow to the Salton Sea. However, there are some laterals that are intercepted by main canals so spillage is conveyed to and held in main canal regulating reservoirs. Also, lateral spillage increases are not actually lost in the interceptor projects areas. Spillage that would be occurring if not for the interceptors and the "interceptor-like" portions of the system is referred to as "potential" lateral spillage.

The main cause of 12-HD induced spillage is associated with timing mismatches between lateral headgate flow decreases relative to farm delivery gate shutoffs or decreases. There is a bias toward having excess water (rather than deficits). This is called the "Shutoff Loss Spillage" or SOLS in the Spillage Report. Furthermore, the only places where actual (as opposed to potential) spillage losses can occur is from Non-Intercepted Laterals.

From Table ES-1 in the Executive Summary or Table _____ in the body of the Spillage Report, the non-intercepted lateral SOLS was estimated to be __,____ AF for the 1997 CFS year (the period from July 1,1997 through June 30, 1998) for FxMWD events (see row XX), which are the 12-HD events. In addition the "Additional Spillage" or AS (associated with the FxMWD events) was estimated to be __,____ AF. Therefore, the Total Spillage associated with all of the 12-HD events is estimated to be __,____ AF.

APPENDIX B

ADDENDUM TO
INITIAL VERIFICATION PROCEDURE
for estimating
NET ON-FARM SAVINGS RESULTING FROM 12-HOUR DELIVERIES
to obtain
REDUCED FARM DELIVERIES (12-HD)
for Projects 9 and 15

this CVC report was initially issued under the following title:

ADDENDUM TO INITIAL VSR (dated September 1996)
PROJECT 9
12-HOUR DELIVERY PROGRAM
VERIFICATION SUMMARY REPORT

PART I:
NET ON-FARM SAVINGS
(draft dated September 1998)

Imperial Irrigation District

Metropolitan Water District of Southern California

Water Conservation Agreement

ADDENDUM TO INITIAL VERIFICATION PROCEDURE for estimating NET ON-FARM SAVINGS RESULTING FROM 12-HOUR DELIVERIES to obtain REDUCED FARM DELIVERIES (12-HD) for projects 9 and 15

Conservation Verification Consultants

Imperial Irrigation District

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INITIAL VERIFICATION PROCEDURE
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for projects 9 and 15

Conservation Verification Consultants

June 30, 1999
(reprint)

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PART I:
NET ON-FARM SAVINGS
(Draft dated August 1998)

Since completing the Initial VSR for Part I in September 1996 a number of changes have been made and or have taken place in the 12-HD Program. This Addendum to the *Project 9 12-Hour Delivery Report, Part I: Net On-Farm Conservation Savings (Dated September 1996)* has been developed to address these changes. The first DRAFT of the Addendum was submitted to the WCMC at the June 20, 1997 meeting and discussed. However, at that time this section on limiting the 12-HD savings was incomplete. A second DRAFT of the Addendum containing a preliminary method for handling the growth of 12-HD usage and accounting for 12-HDs to serve Project 14 and 18 fields was submitted at the January 28 1998 WCMC and discussed. However, this third DRAFT contains CVC's latest strategy for handling the growth in 12-HD usage, an updated validation analysis, and an example computation using a new inference model for determining the on-farm savings associated with 12-HDs.

BACKGROUND

Part I: Net On-Farm Savings of the 12-Hour Delivery Project's Verification Summary Report summarizes the strategies and computational procedures used for developing the net on-farm savings associated with 12-HDs. The basis for the savings associated with the 12-HD events was derived from a random survey of the initiators of 1,656 12-hour orders, which represented approximately every tenth (10^{th}) order during the 1994 water year. The results of this survey were tabulated in what is called the 1-in-10 Grower Database (or 1:10 Database).

Since completion of the Part I in September 1996 a cap of 5 cfs, instead of the standard 7 cfs has been placed on 12-HD orders during the fall (September through November) and spring (March through May) quarters. This has resulted in a decrease in the average savings per 12-HD compared to when the 1:10 Database was developed. Furthermore, during the development of Part II of the 12-HD VSR, *Analysis of Consequential Lateral Spillage*, new insights for handling the 1:10 Database queries regarding the destiny of excess water with the answer "return to Canal" have been developed. Using the new insights to develop a better analytical basis for estimating the potential Effective Utilization, EU, for the "return to Canal" events in the 1:10 Database resulted in a higher EU, which decreases the average net on-farm savings accordingly.

In addition to the above, the CVC is concerned about the effect of the significant growth in the use of 12-HDs since the 1994 water year when the 1:10 Database was developed. For example, during the 1994 water year there were roughly 20,000 12-HDs and during the 1996 water year there were roughly 24,000

12-HDs. To handle this growth in 12-HD usage the CVC has modified the inference model for estimating the net on-farm savings based on the 1:10 Database.

This Addendum contains summaries the following strategies and computational procedures developed to handle: 1) the changes in the net on-farm savings for each 12-HD that are associated with the 5 cfs caps; 2) the effects on EU of the new analytical basis for dealing with the "return to Canal" answers, and 3) increasing usage of 12-HDs. These changes are additive and the most logical place to start is with the EU changes.

REVISED EFFECTIVE UTILIZATION (EU)

It was assumed that a portion of the estimated gross on-farm conservation from a given 12-HD, (v_{24} - v_{12}), may have been effectively used. To account for this, EU percentages were developed for each type of 12-HD order and the gross on-farm conservation savings were reduced by multiplying them by (1.00 - EU/100) to obtain the net savings. The EU percentage was developed from the answers given to the following two part question (this is Item 18 on Form 1, the Order Clerk's Questionnaire for Every Tenth Order):

Part 1: "If 12-HDs were not available, with the flow rate you indicated you would have ordered for 24 hours do you think you would end up with too much water for this irrigation?" ____No ____Yes

Part 2: "If yes, where would the excess water have gone ? (Growers were given the following choice of destinations: same field, SF; directly to the drain, D; another field, same gate, SG; different gate, DG; returned to the canal, C; or other.)"

To analyze the responses to this two part question, the 1:10 Database was separated into two clusters (each representing approximately half of the sample):

- The "H Cluster" for 12-HD orders that the growers said replaced 24-HD orders that would have been equal to **H**alf or 0.5 cfs more than **h**alf of their 12-HD orders; and

- The "S Cluster" for 12-HD orders that the growers said replaced 24-HD orders that would have been the **S**ame as their 12-HD orders or equal to the **M**inimum flow rate (at least 1 cfs greater than half of the 12-HD order) needed for that particular irrigation.

The responses for only 351 or about 20 percent of the total indicated that there would not have been excess water. A total of 646 of the responses (39%) indicated that there would have been excess water, and that it would have been "returned to the canal". A total of 385 of the responses (23%) indicated that the excess water would have been sent directly to the drain. Other possible responses did not represent large portions of the sample.

The judgments of the growers interviewed as well as those of IID field and management personnel at both the division and district levels were integrated in the process of assigning EU percentage for the responses to the above two part question. The logic underlying the assignment of potential Effective Utilization (EU) percentages for the excess water that would occur without 12-HDs, which is the 24-hour excesses, (based on the answers given to Question 18 for every "tenth 12-HD order") is presented in the Initial 12-HD Verification Summary Report: Part I. The EU values used are presented therein in Table 4.

Almost 40% of the growers said they would return their excess water back to the canal. However, during the CVC's grower interviews many growers indicated that prior to the advent of the 12-HD Program canal returns were not common. Thus it was concluded that many of the answers indicating the water was returned to the canal, (C) responses), were not a valid representation of what would have been possible without the 12-HD program. In view of this the following basis was used to obtain the EU value: 1) It was assumed that on average in 25% of the cases the water would have remained and been used on farm, with an EU similar to the weighted average EU for the respective (D), (DG), (SF), and (SG) designations; and 2) An EU of 5% was assumed for the remaining 75% of the (C) responses (see columns C, D, and E in Table 4 in the Initial VSR).

A more comprehensive understanding of lateral canal spillage has been developed since completing Part I. As a result of this new understanding it has been possible to develop an analytical approach (to replace the more subjective approach outlined above) for assigning EU values to the large number of responses for which the growers said they would "return the excess water to the canal".

Lateral Spillage Hydrograph Analysis

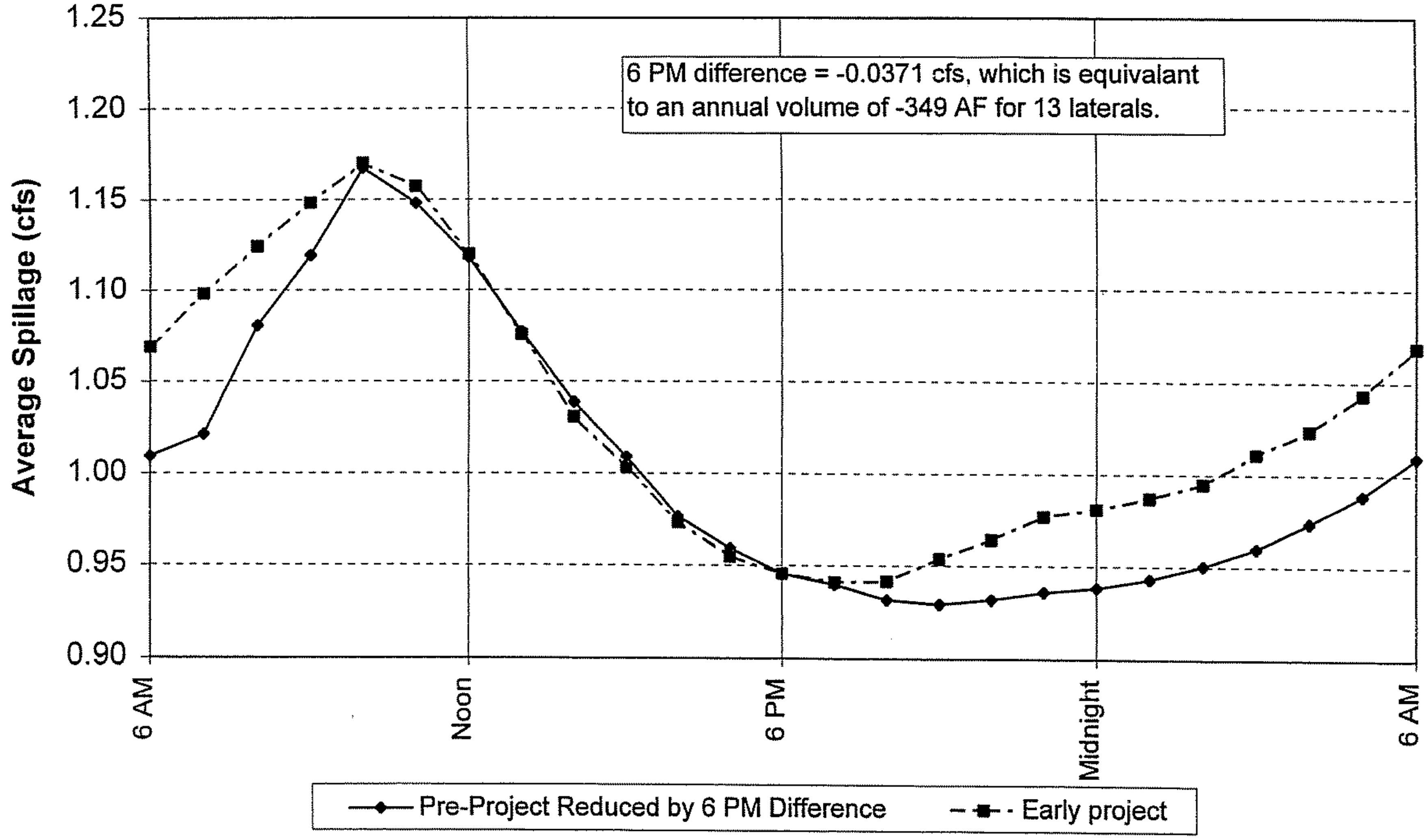
During the development of the 12-HD Verification Summary Report: Part II: *Analysis of Consequential Lateral Spillage*, the lateral spillage hydrographs shown in Figure A-1 were developed. The dashed curve is the early 12-HD Program spillage hydrograph, which is based on the average hourly spillage values for 13 representative laterals from July 1, 1990 through June 30, 1993. The solid curve is the pre-Program spillage hydrograph, which is based on the average hourly spillage for the 13 lateral set from July 1 1985 through June 30, 1990. In addition the pre-Program curve has been shifted down by 0.0371 cfs so it has a common point with the early Program curve at 6 PM.

From the pre-Program spillage hydrograph shown in Figure A-1 it is evident that some additional spillage occurred after 6 PM. But the increase in spillage is only large enough to account for an occasional return of water to a lateral canal. Furthermore, the extra increase in spillage after 6 PM during the early Program as compared to the pre-Program period can be accounted for by the estimated shut-off losses associated with terminating 12-HDs. Therefore, it can be assumed that very little water was ever actually "returned to the Canal"
prior to the 12-HD Program, which provided the additional "Night Patrolmen" necessary to manage the returned water.

Destination of "Returned to Canal" or (C) Responses

For the most part, prior to the 12-HD Program relatively little water was actually returned to canals. It seems reasonable to assume that water would have been consistently returned only from farm delivery gates supplied directly off of main canals or along laterals where the spillage would have been intercepted by other canals. For example like the Thistle laterals, which are intercepted by the Westside Main.

Figure A-1
Combined Spillage of 13 Laterals:
Early and Shifted Pre-Program Hourly Hydrographs



The percent of the District's farm delivery gates that fit the above categories was determined and weighted average EU values were assigned for the water returned from them. Table A-1 provides a listing of these counts and the assigned EU values. The direct delivery gates along the three main canals can be shut without seriously affecting downstream users, so it was assumed that users did return water to the canal from all (100%) of these gates. An EU of 95% was assumed for the direct delivery gates that are upstream from pre-project reservoirs, and an EU of 50% was assumed for the downstream gates.

It was assumed that the users along the intercepted laterals would have only been able to shut their gates about half (50 percent) of time and return water to the canal without adversely affecting other deliveries. For the Fudge and Sperber lateral systems the potential EU of the water returned to the canals was assumed to be 95%. However, for the Thistle laterals the EU was assumed to be only 50% since the Carter reservoir was not yet automated, and for the Vail Supply system it was assumed to be only 10% because most of the returned water would have been spilled at the Vail automatic spill. The weighted average EU for the water returned to the canals from all of the delivery gates listed in Table A-1 is 67%, and the 794 gates listed represents 9.4% of the total number of farm delivery gates served by IID.

New EU Values for (C) Responses and Revised Table 4

Table 4 presented in the 12-HD Verification Summary Report: Part I (dated September 1996) needs to be revised to reflect the new insights for handling the "returned to the canal", (C) responses, to Question 18 in the 1:10 Grower Database. To do this the following basis was used to obtain the EU value: 1) It was assumed that, on average, in 90.6% of the cases the water would have remained and been used on farm, with an EU similar to the weighted average EU for the respective (D), (DG), (SF), and (SG) designations; and 2) For the remaining 9.6% of the (C) responses the weighted average EU of 67% was assumed (see Table A-1) for the water that would have been returned to the canals (see columns C, D, and E in Table A-2).

Table A-2 is formatted the same as Table 4 and all of the base counts and EU percentages are the same except for the changes in the division of counts and EU values used for the (C) responses. The overall effect of making these changes increases the global volume weighted average EU from 12.0 to 16.0%. The global volume weighted average EU is computed by dividing the difference between the sums of the estimated gross and net savings by the sum of the estimated gross savings from all of the 12-HD events that make up the 1:10 Grower Database.

Effect of Using the New EU Values on the Net On-Farm Savings

The relative effect on the Water Conservation Savings for Project 9 of the revisions in the EU presented above can best be demonstrated by comparing the net on-farm savings value obtained for the 1997 Projection with projections using these revisions and the same (1996) data.

The Conservation Element, which is the net on-farm savings, used in the Project 9 savings projection was 44,459 AF (actually it would have been 45,724 AF except for a transposing error). The effect of using the revised EU values for the "returned to the canal" responses alone without changing the

Table A-1
Computation of Effective Utilization (EU) Fraction for Deliveries Returned to Canal

Category	Canal Group	Portion	Gate Opportunity	Gate Count By Group	Gate Count Distribution	Gate Count By Portion	Gate Count By Opportunity	EU Fraction	EU x Opportunity
Direct Delivery	CM	All (U/S of Fudge Reservoir)	100%	19	100%	19	19	95% [1]	18.05
Direct Delivery	EHL	U/S of Singh Reservoir	100%	37	75%	27.75	27.75	95% [1]	26.36
Direct Delivery	EHL	D/S of Singh Reservoir	100%		25%	9.25	9.25	50%	4.63
Interceptor-Like	Fudge	Designated FU	50% [2]	84	100%	84	42	95%	39.90
Interceptor-Like	Sperber	Designated SP	50% [2]	224	100%	224	112	95% [1]	106.40
Interceptor-Like	Thistle	Designated TH	50% [2]	239	100%	239	119.5	50% [3]	59.75
Interceptor-Like	Vail	Designated V	50% [2]	117	100%	117	58.5	10%	5.85
Direct Delivery	WSM	U/S of Sheldon Reservoir	100%	74	40%	29.6	29.6	95% [1]	28.12
Direct Delivery	WSM	D/S of Sheldon Reservoir	100%		60%	44.4	44.4	50%	22.20
Total			---	794	---	794	462 [4]	---	311.26
Weighted Average			---	---	---	---	---	67%	---

Notes:
1 Corresponding reservoir was in operation during pre-program period.
2 Reflects likelihood that half of users were close enough to the lateral end to return water without adversely affecting other deliveries.
3 Corresponding reservoir did not exist during pre-program period.
4 Represents 9.4 % of total number of gates in IID (0.094 = 462 / 4898).

Table A-2
Revised Computation of Effective Utilization (EU) Fractions

Answers to Question 18: Part 1 (Would 24-HD result in excess water?)	Part 2 (Destination of excess): Code	Part 2: Description	Count of 1-in-10 Data (A)	EU* (B)	Wt. Ave. EU (C)	EU* (D)	Distrib. of C* (E)	Wt. Ave. EU (F)	Wt. Ave. EU for Class (G)	Resulting EU: t <= 10.5 hr (H)	Resulting EU: t > 10.5 hr (H')	Destination Code
For "H Cluster" Orders												
Yes	D	Drain	165	0%	7%				10%	0%	0%	D
	DG	Different gate	10	50%						50%	0%	DG
	SF	Same field	34	10%						10%	0%	SF
	SG	Different field, same gate	12	50%						50%	0%	SG
	C	Kept on-farm	247			7%	90.6%	12%		12%	0%	C
		Canal				67%	9.4%					
		Unspecified	29							10%	0%	U
Other		All answers	10									
No		All answers	247									
For "S Cluster" Orders												
Yes	D	Drain	220	0%	12%				14%	0%		D
	DG	Different gate	39	50%						50%		DG
	SF	Same field	70	10%						10%		SF
	SG	Different field, same gate	32	50%						50%		SG
	C	Kept on-farm	399			12%	90.6%	17%		17%		C
		Canal				67%	9.4%					
		Unspecified	27							14%		U
Other		All answers	11									
No "M Class"		All answers	19									
"S Class"		All answers	85	50%						50%		N/S
Total			1,656	**Global Volume Weighted Average**						16.0%		

* Assumed values based on CVC interviews with selected growers.

inference model would have reduced the correct value of 45,724 AF to 44,155 AF. This is a reduction of 1,569 AF of 3.4%.

REVISED INFERENCE MODEL FOR USE WITH 5 cfs CAPS

The inference model presented in the 12-HD Verification Summary Report: Part I (dated September 1996) for computing the net on-farm conservation savings was not designed to accommodate relative changes in 12-HD order sizes that differ from those in the 1:10 Database. When the 1:10 Database was developed the cap was 7 cfs throughout the year. However, the 5 cfs caps on morning (AM) orders beginning with the spring of 1996 (and every spring and fall thereafter) have resulted in significantly altering the relative numbers of orders in the order tiers above 4.5 cfs as compared to when the cap was 7 cfs.

Order Tiers and Counts by Season

The following observations can be made by comparing the counts in each order tier in the 1:10 Database with those in the current District-wide Zanjero (QTDB) Database (see Table A-3):

- The relative numbers of counts in all order tiers is reasonably similar between the two databases during the winter and summer periods when both have 7 cfs caps.

- During the spring and fall when the 5 cfs cap was imposed the relative numbers of counts in the order tiers of 4 cfs or less are similar between the two databases.

- During the spring the percentage of the total counts in all order tiers greater than 4 cfs is about the same in both databases. However, in the spring of 1996 (represented by the QTDB column) there were hardly any orders above 5 cfs although evening (PM) orders up to 7 cfs were allowed. Thus it appears that 4.5 and 5 cfs orders were used in place of most of the 5.5 cfs and larger AM orders.

- Similar comparisons can be made for the fall of 1996. However, the reason there were still so many orders greater than 5 cfs in the QTDB column is because the fall data is a composite of September and October 1996 data when the 5 cfs cap was in place and November 1995 data when the old 7 cfs cap was still being used.

Seasonal Average Savings by Order Tier

Table A-4 shows the average net on-farm savings per 12-HD by order tier annually and by season derived from the 1:10 Grower Database. The differences between the savings for any given order tier are fairly large in some cases, which is probably due to the different crops and irrigation methods that predominate in any given season. Therefore, it was decided to maintain "seasonality" as much as possible in the inference model.

Table A-3. Combined AM & PM Delivery Counts by Order Tier and Season[1]

Order Tiers (cfs)	Winter		Spring		Summer		Fall	
	1in10[1]	QTDB[2]	1in10	QTDB	1in10	QTDB	1in10	QTDB
Counts								
0.5 and 1.0	13	633	32	694	15	360	32	560
1.5 and 2.0	41	832	123	1217	21	380	77	1166
2.5 and 3.0	69	914	92	899	38	460	107	1503
3.5 and 4.0	48	831	47	888	43	414	69	920
4.5 and 5.0	43	910	58	2563	46	888	113	1744
5.5 and 6.0	24	540	54	88	36	484	34	241
6.5 and larger	47	1058	118	251	135	1398	81	375
Subtotals	285	5718	524	6600	334	4384	513	6509
						Grand Totals	1656	23211
Percent of Sample								
0.5 and 1.0	5%	11%	6%	11%	4%	8%	6%	9%
1.5 and 2.0	14%	15%	23%	18%	6%	9%	15%	18%
2.5 and 3.0	24%	16%	18%	14%	11%	10%	21%	23%
3.5 and 4.0	17%	15%	9%	13%	13%	9%	13%	14%
4.5 and 5.0	15%	16%	11%	39%	14%	20%	22%	27%
5.5 and 6.0	8%	9%	10%	1%	11%	11%	7%	4%
6.5 and larger	16%	19%	23%	4%	40%	32%	16%	6%
Totals	100%	100%	100%	100%	100%	100%	100%	100%
Selected Percents								
(4.5 and 5) of all	15%	16%	11%	39%	14%	20%	22%	27%
(4.5 and 5) of (0.5 to 5)	20%	22%	16%	41%	28%	35%	28%	30%
(4.5 and larger) of all	40%	44%	44%	44%	65%	63%	44%	36%

Notes:

[1] The seasons are: Winter: December - February; Spring: March - May; Summer: June - August; and Fall: September - November.

[2] The 1-in-10 sample was collected between October 1, 1993 and September 30, 1994, inclusive.

[3] The QTDB sample was collected between November 1995 through October 1996, inclusive.

Table A-4. Average 12-HD On-Farm Savings in AF by Order Tier and Seasons[1] for 1:10 Grower Database

Order Tiers (cfs)	Winter	Spring	Summer	Fall	Annual
0.5 and 1.0	0.78	0.72	0.60	0.67	0.70
1.5 and 2.0	1.51	1.38	1.24	1.38	1.39
2.5 and 3.0	1.56	1.68	1.66	1.88	1.72
3.5 and 4.0	1.85	1.80	2.05	2.13	1.98
4.5 and 5.0	2.35	2.18	2.31	2.12	2.21
5.5 and 6.0	2.04	2.09	2.51	2.93	2.38
6.5 and larger	2.41	2.39	2.45	2.54	2.44
Average	1.87	1.82	2.14	1.99	1.94
				Overall Average	1.94

Note:

[1] The seasons are: Winter: December - February; Spring: March - May; Summer: June - August; and Fall: September - November.

Inference Model Development

The general equation for the inference model is:

$$\text{Total Savings} = [n_1 \times (v_c)_1] + [n_2 \times (v_c)_2] \ldots\ldots\ldots\ldots + [n_m \times (v_c)_m]$$

where:

$n_1, n_2, \ldots.. n_m$ represent the number of 12-HD events in a given sub-set of the database, and
$(v_c)_1, (v_c)_2, \ldots.. (v_c)_m$ represent the average savings per event in each subset.

A constraint to the development of an inference model is the database size coupled with the necessity of having a sufficiently large threshold number of events in each of its sub-sets to obtain statistically reliable average savings values, $(v_c)_X$, for each of them. A statistically reliable threshold is 30 events per sub-set and the 1:10 Database contains data for 1656 12-HD events. Therefore, even if the events were equally distributed among sub-sets the maximum number of sub-sets would only be 1656/30 = 55.

In view of the above discussions concerning Tables A-3 and A-4, a logical starting point for developing the inference model would be to divide the 1:10 Database into sub-sets representing: the four irrigation methods; the four seasons; and the seven order tiers represented. However, this would result in having too many (4 x 4 x 7 = 112) sub-sets.

The first effort at reducing the number of sub-sets was to consolidate the order tiers into three groups designated as: 1-4, for orders from 0.5 to 4.0 cfs; 5, for 4.5 and 5.0 cfs orders; and 6-7, for orders of 5.5 cfs or larger. The logic behind consolidating the 1-4 tiers is based on the fact that the 5 cfs cap did not greatly affect the numbers of orders of 4 cfs or less and the average annual savings for the orders larger than 5 cfs are nearly the same (see Table A-3). Consolidating the order tiers into three groups reduced the number of possible data sub-sets to 48. The 1:10 Database was divided into these 48 sub-sets and the average savings per event in each sub-set was determined. The results of this screening process are presented in Table A-5.

Many of the sub-sets presented in Table A-5 have too few events to be statistically reliable $(v_c)_X$ values. So the next step in developing the inference model was to strategically consolidate the sub-sets so each had at least 30 events and uniqueness between sub-sets was preserved as much as practical (as measured by average savings while considering the number of events involved). The following was done to accomplish this:

- All drip events were consolidated because there were so few drip events in most of the sub-sets.

- The sprinkler events in all four seasons were combined for each of the three order tier groups. This was done because there were very few events in many of the sub-set cells and the differences in the savings were not large within order tier groups for the sub-sets with the larger numbers of counts.

Table A-5. Number of Counts and Average Savings in Sub-sets of the 1:10 Grower Database				
Sub-set Criteria			Sub-set	
Order Tier (cfs)	Irrigation Method	Season	Counts	Average Vc (AF)
0.5 through 4.0	drip	1w	9	1.42
0.5 through 4.0	drip	2sp	123	1.56
5.5 through 7.0	drip	2sp	2	0.86
0.5 through 4.0	drip	3su	14	2.09
0.5 through 4.0	drip	4f	6	1.38
4.5 and 5.0	drip	4f	2	2.48
0.5 through 4.0	flat	1w	11	1.52
0.5 through 4.0	flat	2sp	58	1.37
0.5 through 4.0	flat	3su	55	1.39
0.5 through 4.0	flat	4f	38	0.96
0.5 through 4.0	row	1w	110	1.60
0.5 through 4.0	row	2sp	96	1.47
0.5 through 4.0	row	3su	35	1.60
0.5 through 4.0	row	4f	55	1.71
0.5 through 4.0	sprinkler	1w	39	1.56
0.5 through 4.0	sprinkler	2sp	16	1.18
0.5 through 4.0	sprinkler	3su	9	2.17
0.5 through 4.0	sprinkler	4f	182	1.83
4.5 and 5.0	flat	1w	5	2.64
4.5 and 5.0	flat	2sp	13	2.85
4.5 and 5.0	flat	3su	25	2.35
4.5 and 5.0	flat	4f	17	0.94
4.5 and 5.0	row	1w	19	2.46
4.5 and 5.0	row	2sp	39	1.93
4.5 and 5.0	row	3su	13	2.59
4.5 and 5.0	row	4f	20	2.29
4.5 and 5.0	sprinkler	1w	19	2.17
4.5 and 5.0	sprinkler	2sp	6	2.41
4.5 and 5.0	sprinkler	3su	4	1.94
4.5 and 5.0	sprinkler	4f	74	2.34
5.5 through 7.0	flat	1w	33	2.14
5.5 through 7.0	flat	2sp	88	1.93
5.5 through 7.0	flat	3su	142	2.57
5.5 through 7.0	flat	4f	59	2.49
5.5 through 7.0	row	1w	34	2.28
5.5 through 7.0	row	2sp	70	2.59
5.5 through 7.0	row	3su	23	1.84
5.5 through 7.0	row	4f	30	3.02
5.5 through 7.0	sprinkler	1w	4	3.51
5.5 through 7.0	sprinkler	2sp	5	3.66
5.5 through 7.0	sprinkler	3su	3	3.09
5.5 through 7.0	sprinkler	4f	25	2.70

- The winter + summer and the spring + fall events were combined for the following: the 1-4 tier group for flat irrigation; the 5 tier group for flat irrigation; and the 5 tier group for row irrigation. This was done to obtain at least 30 events for each of the respective sub-sets and also match the timing when the 5 cfs cap is applied.

- The remaining sub-sets were kept separate because each contained a sufficient number of events.

This consolidation reduced the number of sub-sets presented in Table A-5 to 22. The number of events and the average savings of each of these 22 sub-sets of the 1:10 Database are presented in Table A-6. Examples for interpreting the Inference Sub-Sets, see left hand column of Table A-6, are as follows:

Row 2, flat1_4spf, is flat irrigation with delivery rates between 0.5 to 4.0 cfs in the spring and fall;

Row 15, row5wsu, is row irrigation with delivery rates of 4.5 and 5.0 cfs in the winter and summer; and

Row 22, sp6_7, is sprinkler irrigation with delivery rates between 5.5 to 7.0 cfs in all seasons of the year.

The annual net on-farm conservation savings of the 12-HD Program can be estimated by substituting the average savings values for each Inference Sub-Set and the associated numbers of 12-HDs throughout IID for the corresponding sub-set category in the general equation for the inference model presented at the beginning of this sub-section.

Comparisons Between Old and New Net On-Farm Savings

The relative effect on the Water Conservation Savings for Project 9 of the revision in the inference model presented above can best be demonstrated by comparing the net on-farm savings value obtained for the 1997 Projection with projections using these revisions and the same (1996) data.

The Conservation Element, which is the net on-farm savings, used in the Project 9 savings projection was 44,459 AF (actually it would have been 45,724 AF except for a transposing error). As discussed above the effect of using the revised EU without changing the inference model would have reduced the correct on farm savings value of 45,724 AF to 44,155 AF. This is a reduction of 1,569 AF of 3.4%.

By using both the revised EU values and the new inference model the net on-farm savings would become 42,808 AF (see Table A-6). This represents a further reduction of (44,155 - 42,808) 1,347 AF or another 2.9%, giving a total reduction of (45,724 - 42,808) 2,916 AF or 6.4%

The total net on-farm savings for the 1,656 12-HDs in the 1:10 Database was estimated to be 3,384 AF using the old EU values and Inference Model. Using the new EU values and Inference Model it is 3,224 AF, which is a reduction of 160 AF or 4.7%.

Table A-6. Estimated Net On-Farm 12-HD Savings Using 1996 Zanjero Data with the Revised EU Values in the New Inference Model					
Inference Sub-Set[1]	1 in 10 Database			1996 Zanjero Data	
	Count	Avg Vc (AF)	Sum Vc (AF)	Count	Vc (AF)
1.drip	156	1.597	249	2,201	3,514
2. flat1_4spf	96	1.209	116	1,406	1,700
3. flat1_4wsu	66	1.411	93	1,254	1,770
4. flat5spf	30	1.770	53	1,521	2,692
5. flat5wsu	30	2.399	72	689	1,653
6. flat6_7f	59	2.490	147	290	722
7. flat6_7sp	88	1.928	170	223	430
8. flat6_7su	142	2.565	364	1,408	3,612
9. flat6_7w	33	2.143	71	609	1,305
10. row1_4f	55	1.707	94	1,183	2,019
11. row1_4sp	96	1.465	141	1,197	1,754
12. row1_4su	35	1.603	56	278	446
13. row1_4w	110	1.598	176	1,579	2,523
14. row5spf	59	2.049	121	1,428	2,926
15. row5wsu	32	2.515	80	656	1,650
16. row6_7f	30	3.020	91	220	664
17. row6_7sp	70	2.586	181	151	390
18. row6_7su	23	1.842	42	400	737
19. row6_7w	34	2.275	77	601	1,367
20. sp1_4	246	1.760	433	3,593	6,325
21. sp5	103	2.298	237	1,476	3,392
22. sp6_7	37	2.951	109	373	1,101
Subtotal	1,630	—	3,173	22,736	42,693
Wt. Avg	—	1.947	—	—	—
Unspecified	26	1.947	51	58	113
Total	1,656	—	3,224	22,794	42,806

Note:
[1] Examples for interpreting the inference sub-set symbols are:
Row 2: flat1_4spf is flat irrigation with delivery rates between 0.5 and 4.0 cfs in the spring and fall.
Row 15: row5wsu is row irrigation with delivery rates between 4.5 and 5.0 cfs in the winter and summer.
Row 22: sp6_7 is sprinkler irrigation with delivery rates between 5.5 and 7.0 cfs in all seasons.

Weighted averages. The 12-HD 1:10 Database includes data for 1656 12-HD events. The global weighted average 12-HD order = 4.26 cfs and the global volume weighted average EU = 16.0% (compared to 12.0% previously) for the 1:10 Database (see Table A-2). Furthermore, the average net on-farm savings per 12-HD = 1.95 AF (see Table A-6). This is 4.4% less than its previous value, which was 2.04 AF.

NEW INFERENCE MODEL TO HANDLE GROWTH IN 12-HD USAGE[1]

The CVC is concerned about the effect of the significant growth in the use of 12-HDs since the 1994 water year when the 1:10 Database was developed. For example, during the 1994 cfs (July 1 - June 30) year there were 20,078 12-HDs and during the 1997 cfs year there were 24,316 12-HDs. It appears that more growers are electing to use 12-HDs or finding new ways to use them. To handle this growth in 12-HD usage the CVC has modified the inference model for estimating the net on-farm savings based on the 1:10 Database.

It seem logical that the average savings per 12-HD would be lower for additional events, except in the case of the increased acreage under drip and sprinkle irrigation. This is because the types of 12-HD uses rendering the largest savings would likely have been captured by the 12-HD Program early on. Therefore, more and more of the 12-HDs may be focused on labor and management savings with less potential for water savings.

Field Visits and Office Analysis

In February the CVC interviewed six growers/managers who are major users of 12-HDs and queried them as to their opinions concerning any change in usage since 1994. None of them felt they had significantly changed their strategy or decision making process for ordering 12-HD. During April 1998 the CVC with the help of IID's Water Resources Team visited fields served by the delivery gates that had received the largest numbers of 12-HDs during 1997. A summary of some of the field observations and WIS data analysis is presented in Table A-7.

From the field observations, discussions with growers and an analysis of the 12-HD data it appears the growth in usage has occurred in the following three domains. Firstly, the relative numbers of 1 to 2 cfs 12-HD orders to serve small surface irrigated fields and drip and sprinkle irrigation systems has increased. Secondly, there has been *extensive* growth with 12-HDs being made to more delivery gates during any given season of the year. Thirdly, there has been *intensive* growth as the average number of 12-HDs per delivery gate (that is the total number of 12-HDs divided by the total number of farm delivery gates receiving 12-HDs) has increased, while the number of gates receiving 12-HDs has remained relatively constant (see Figure A-2).

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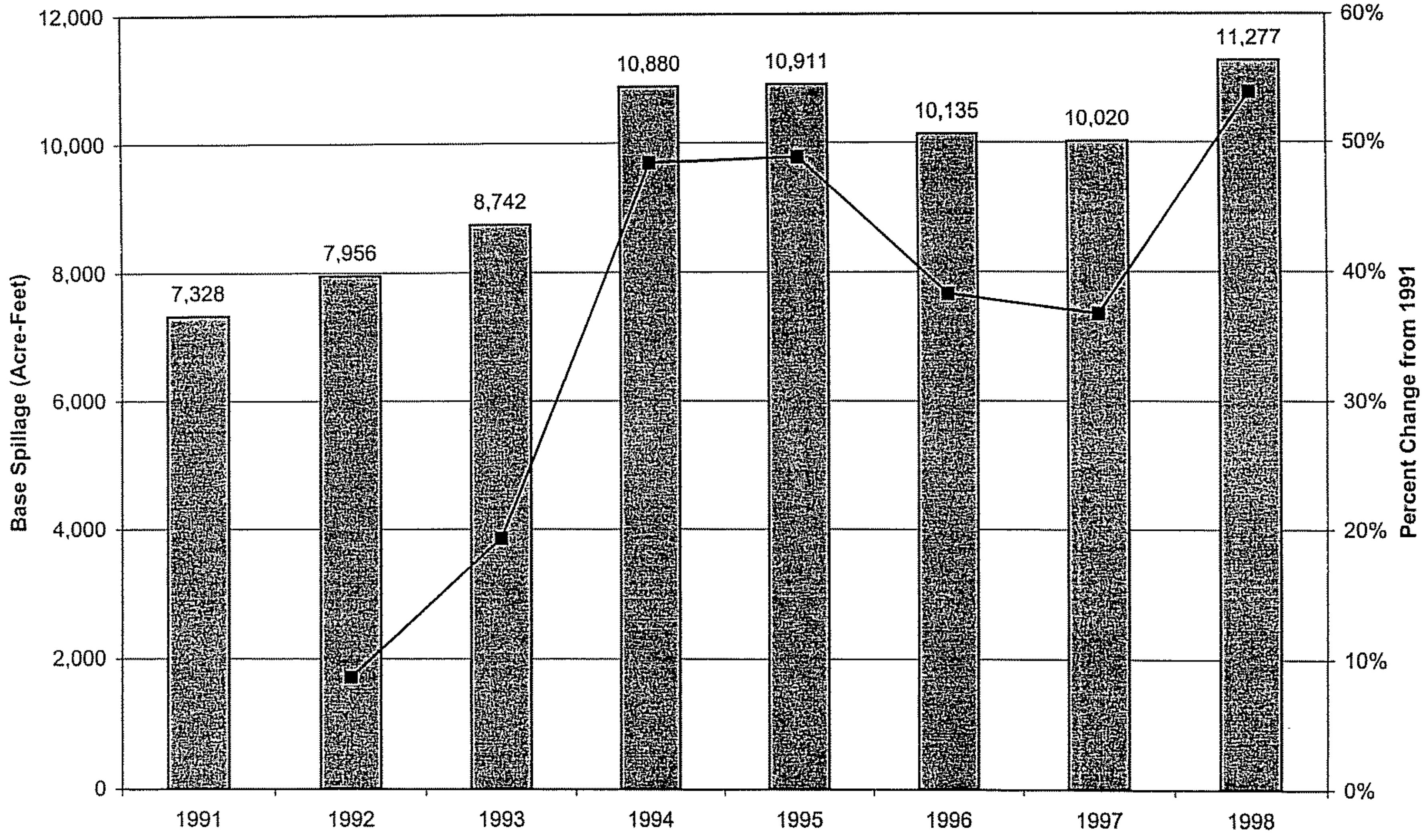
1 This section replaces the section titled "Limiting Conservation Savings Resulting From the Growth in 12-HD Usage" in the January 1998 DRAFT of this Addendum. It was first submitted to the WCMC at the September 24, 1997 meeting and discussed therein.

Table A-7. Field and Office Analysis of Top 20 Gates Serving Fields with the Greatest 12-Hour Delivery Usage in 1997.

No.	Gate	Net Ag Acres 1997	# Active Tenants 1997	# 12-HDs 1994	# 12-HDs 1997	Change in 12-HDs 1997	Average AF/12-HD 1997	Observed Method 1998	Observed Use 1998	Reported Crop 1997	Notes
1	FIL9B	306	2	97	289	192	0.80	Solid set [1]	Mixed leafy veg	Mixed Lettuce & Broccoli F/W/Sp, Sesbania Su	The farm is on the high side of the canal. The inlet ditch is wide and provides some storage.
2	EHL34	500	2	0	150	150	4.80	Drip	Citrus	Mixed Citrus, Jojoba Su	Farm is on high side of canal. Jojoba has been allowed to die.
3	OAK1	54	1	97	148	51	2.10	Drip	Artichoke	Artichoke F/W/Sp, Flooding Su	An original drip irrigated field.
4	RW37A	5	6	116	147	31	0.40	Flat	Ranchettes	Pasture, Entry error	NOT CODE 250 or 252
5	ELD35	113	2	3	146	143	4.50	Solid set	Newly planted	Sugar Beets, Asparagus, Sudan	
6	SD22A	33	1	0	144	144	1.20		Bare field	Lettuce, Green; Flooding	Operation moved to a different field (See entry 19).
7	ROS14	3	19	11	143	132	0.30	Flat	Ranchettes	Entry error	NOT CODE 250 or 252
8	WSM93	137	1	8	142	134	0.08	Drip	Citrus	Lemons, Oranges	Old citrus converted to drip
9	HHL10	477	1	18	132	114	4.70	Drip	Citrus	Lemons, Oranges	NOT CODE 250 or 252 (rate 255 Mesa Lands)
10	WSM83A	83	1	0	125	125	0.02	Drip	Citrus	Watermelons, Flooding	New citrus with micro-irrigation.
11	WSM97	87	4	4	118	114	0.05	Drip	Citrus	Lemons	New citrus with micro-irrigation.
12	THM14B	137	2	18	104	86	0.10	Row	Carrots	Potatoes; Alfalfa; Carrots	Sandy field with frequent irrigation applications.
13	OAK8	49	1	90	98	8	1.20	Drip	Cucumbers or melon	Artichoke	Blue slip, 0.6 cfs.
14	MAL2	71	1	5	95	90	1.90	Solid set [1]	Mixed leafy veg	Lettuce, Mixed	
15	FER44A	82	2	29	95	66	4.70	Probably Drip	Alfalfa, Citrus & Asparagus	Asparagus, Lemons, Alfalfa	Weedy citrus (lemons). No micro emitters. Healthy asparagus, going to seed.
16	AAC23	298	3	30	91	61	3.00	Siphon tubes	Carrots, kale, Plowing cabbage	Lettuce; Carrots; Broccoli; Sudan Grass	Newly prepared, looks like melons.
17	FIL12A	244	3	13	89	76	1.30	Solid set [1]	Mixed lettuce F/W/Sp	Lettuce, Mixed; Mustard; Sesbania	Typical field of various small leaf lettuce.
18	T14266	95	1	35	82	47	2.10	Drip/sp	Potatoes	Tomatoes, spring; Carrots	Just converted to solid set.
19	DAH46	72	2	0	81	81	1.50	Solid set [1]	Mixed leafy veg	Lettuce, Mixed	
20	N4	150	3	0	79	79	4.40	Solid set [1]	Citrus	Lemons	Young trees. Thin gauge plastic "pipe" to drip lines. No pump.

[1] Lettuce, parsley, etc., planted in strips, is managed for long-term, staggered frequent harvest of small leaves. Alternate strips are sprinkle irrigated daily with short sets.

Figure A-1. Computed Verification Laterals Base Spillage for Water Years 1991 through 1998



Accommodating the Increased Usage of Small cfs Orders

The inference model that was designed to handle the 5 cfs cap had 22 sub-sets. Order sizes (or tiers) equal to or less than 4 cfs were grouped together (see Table A-6). This is satisfactory as long as the relative distribution of order sizes remains the same as in 1994 when the 1:10 Database was developed. However, the relative distribution of order sizes has increased especially the 1 and 2 cfs 12-HD orders. Four new sub-sets of the 1:10 Database were created by combining all 0.5, 1, 1.5, and 2 cfs orders to handle the relative increase in small-cfs orders. For the most part, this still maintained the integrity of the inference model since there are still 23 or more events in each of the inference model's sub-sets or bins (see Tables A-6 and A-8).

Table A-9 shows the comparison between using the new 26 and previous 22 sub-sets to estimates the total 12-HD net on-farm savings using WIS data for the 1997 CFS year (July 1 - June 30) and the revised EU values. (This comparison is made without any further adjustment for growth in order to demonstrate the effect of the relatively greater growth in small 12-HDs since 1994.) Using the new model results in reducing the estimated savings by 870 AF[2] (see Table A-9).

Accommodating the Extensive and Intensive Growth in 12-HD Usage Since 1994

As mentioned above, the growth in the usage of 12-HDs has been both extensive and intensive. To better explain the difference between extensive and intensive growth consider Table A-10, which shows the change in 12-HD usage between 1994 and 1997 for inference Sub-set 24 (for all 1-cfs orders). The *extensive* part of the growth is represented by the roughly 25 percent increase in the number of gates (205 in 1994 and 283 in 1997) receiving 1-cfs 12-HDs. The *intensive* part of the growth is represented by the relatively large increase in the average number of 1-cfs 12-HDs per gate (4.0 in 1994 and 6.7 in 1997).

Extensive growth. It was assumed that the part of the increased growth in usage in each of the 26 inference sub-sets that is attributed to extensive growth would have the same average savings per 12-HD event in its sub-set "*m*", $(v_c)_m$, as was estimated from the 1:10 Database. Thus in the case of inference Sub-set 24 in which the average number of 12-HDs per gate was 4.0 in 1994, the estimated savings for the 4.0 x 283 = 1,132 events (see Table A-10) included within the extensive portion of the growth would be $(v_c)_{24}$ = 0.784 AF/12-HD (see Sub-set "*m*" # 24 in Table A-8).

Intensive growth. For the intensive portion of the growth in 12-HD usage since the 1:10 Database was developed in 1994 it seems reasonable to apply the linear reduced conservation savings strategy depicted in Figure A-3. The horizontal portion in Figure A-3 represents the entire extensive portion of usage where the savings per 12-HD is equal to the full value of $(v_c)_m$. The sloped portion represents the extensive portion of usage where the savings per additional 12-HD is decreased linearly from the full value of $(v_c)_m$ to zero. The rate of decrease depends on the value assigned to k_m for each sub-set "*m*".

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2 It is interesting to note that in the case of the 1:10 Database there is practically not difference between the estimated savings from either inference model (compare Tables A-6 and A-8).

Table A-8. The 1:10 Database with the Counts and the Per Event and Total net On-Farm Savings Using the Revised EU Values for Each of the 26 Inference Sub-sets.

Inference Sub-Set[1]	1 in 10 Database Count	Avg Vc (AF)	Sum Vc (AF)
1.drip3_7	45	2.250	101
2. flat3_4spf	49	1.464	72
3. flat3_4wsu	46	1.672	77
4. flat5spf	30	1.770	53
5. flat5wsu	30	2.399	72
6. flat6_7f	59	2.490	147
7. flat6_7sp	88	1.928	170
8. flat6_7su	142	2.565	364
9. flat6_7w	33	2.143	71
10. row3_4f	39	1.859	73
11. row3_4sp	67	1.609	108
12. row3_4su	25	1.810	45
13. row3_4w	81	1.651	134
14. row5spf	59	2.049	121
15. row5wsu	32	2.515	80
16. row6_7f	30	3.020	91
17. row6_7sp	70	2.586	181
18. row6_7su	23	1.842	42
19. row6_7w	34	2.275	77
20. sp3_4	161	2.033	327
21. sp5	103	2.298	237
22. sp6_7	37	2.951	109
23. all0.5	23	0.430	10
24. all1	69	0.784	54
25. all1.5	107	1.267	136
26. all2	155	1.472	228
Subtotal	1,637	---	3,180
Wt. Avg	---	1.942	---
Unspecified	19	1.942	51
Total	1,656	---	3,231

[1] Examples for interpreting the inference sub-set symbols are:
Row 2: flat3_4spf is flat irrigation with delivery rates between 2.5 and 4.0 cfs in the spring an
Row 15: row5wsu is row irrigation with delivery rates between 4.5 and 5.0 cfs in the winter ar
Row 22: sp6_7 is sprinkler irrigation with delivery rates between 5.5 and 7.0 cfs in all season
Row 23: all0.5 is for all methods with delivery rates of 0.5 in all seasons.

Table A-9. Comparison Between the Estimated Net On-Farm 12-HD Savings Using 1997 WIS Data with the Revised EU Values in the 26 and 22 Inference Sub-sets Models without Adjusting for Growth in Usage.

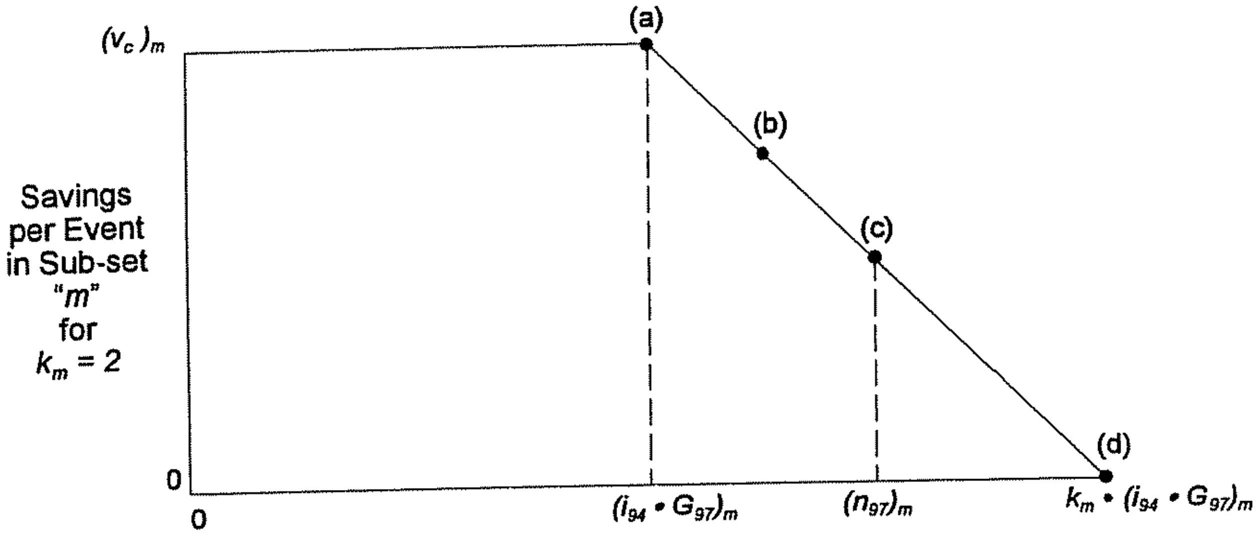
1997 WIS 12HD Data Using 26 Inference Sub-sets			1997 WIS 12HD Data Using 22 Inference Sub-sets			Differences	
Inference Sub-set[1]	Count	Sum Vc (AF)	Inference Sub-set[1]	Count	Sum Vc (AF)	Count	Sum Vc (AF)
1. drip3_7	807	1,816	1.drip	2090	3,337	-1283	-1521
2. flat3_4spf	823	1,205	2. flat1_4spf	1307	1,580	-484	-376
3. flat3_4wsu	858	1,435	3. flat1_4wsu	1337	1,887	-479	-452
4. flat5spf	1621	2,869	4. flat5spf	1621	2,869	0	0
5. flat5wsu	827	1,984	5. flat5wsu	827	1,984	0	0
6. flat6_7f	93	232	6. flat6_7f	93	232	0	0
7. flat6_7sp	113	218	7. flat6_7sp	113	218	0	0
8. flat6_7su	1348	3,458	8. flat6_7su	1348	3,458	0	0
9. flat6_7w	361	774	9. flat6_7w	361	774	0	0
10. row3_4f	693	1,288	10. row1_4f	1173	2,002	-480	-714
11. row3_4sp	708	1,139	11. row1_4sp	1254	1,837	-546	-698
12. row3_4su	183	331	12. row1_4su	407	653	-224	-321
13. row3_4w	1107	1,828	13. row1_4w	1658	2,649	-551	-822
14. row5spf	1355	2,777	14. row5spf	1355	2,777	0	0
15. row5wsu	786	1,977	15. row5wsu	786	1,977	0	0
16. row6_7f	68	205	16. row6_7f	68	205	0	0
17. row6_7sp	70	181	17. row6_7sp	70	181	0	0
18. row6_7su	309	569	18. row6_7su	309	569	0	0
19. row6_7w	278	633	19. row6_7w	278	633	0	0
20. sp3_4	2084	4,237	20. sp1_4	3786	6,665	-1702	-2427
21. sp5	1329	3,054	21. sp5	1329	3,054	0	0
22. sp6_7	320	944	22. sp6_7	320	944	0	0
23. all0.5	471	203				471	203
24. all1	1905	1,494				1905	1494
25. all1.5	948	1,201				948	1201
26. all2	2452	3,609				2452	3609
Subtotal	21,917	39,660		21,890	40,485	27	-825
Wt. Avg	---	---		---	---	---	---
Unspecified	37	72		64	117	-27	-45
Total	21,954	39,732		21,954	40,602	0	-870

[1] Examples for interpreting the inference sub-set symbols are:

Row 2: flat3_4spf is flat irrigation with delivery rates between 2.5 and 4.0 cfs in the spring and fall.
Row 15: row5wsu is row irrigation with delivery rates between 4.5 and 5.0 cfs in the winter and summer.
Row 22: sp6_7 is sprinkler irrigation with delivery rates between 5.5 and 7.0 cfs in all seasons.
Row 23: all0.5 is for all methods with delivery rates less than or equal 0.5 in all seasons.

Table A-10. Summary of 12-HD Usage During Water Years 1994 and 1997 for Inference Sub-set 24 (all 1-cfs orders) Showing Deliveries per Gate, Number of Gates and Total Deliveries Based on WIS Data.

1994 Water Year			1997 Water Year		
Deliveries Per Gate	Number of Gates	Total Deliveries	Deliveries Per Gate	Number of Gates	Total Deliveries
			131	1	131
			121	1	121
			116	1	116
			112	1	112
			96	1	96
87	1	87			
71	1	71			
69	1	69			
			68	1	68
			66	1	66
			45	2	90
			43	1	43
			36	1	36
			35	1	35
			34	1	34
30	1	30			
27	1	27			
			24	1	24
			23	1	23
22	1	22	22	1	22
			21	2	42
			20	1	20
17	1	17	17	4	68
16	1	16			
			15	2	30
14	2	28	14	2	28
13	1	13	13	5	65
12	3	36	12	2	24
11	4	44	11	4	44
			10	3	30
9	3	27	9	1	9
			8	4	32
7	1	7	7	3	21
6	6	36	6	12	72
5	7	35	5	15	75
4	5	20	4	15	60
3	16	48	3	22	66
2	34	68	2	33	66
1	115	115	1	137	137
Total Gates	205			283	
Total Deliveries		816			1906
Avg Deliveries/Gate		4.0			6.7



Point	Commentary
(a)	Each 12-HD event in subset "*m*" saves $(v_c)_m$ up to $(i_{94} \cdot G_{97})_m$ events
(b)	The average savings for the number of 1997 events in sub-set "*m*" in excess of $[n_{97} - (i_{94} \cdot G_{97})]_m$ events, which equals $R_m \cdot (v_c)_m$
(c)	The estimated reduced savings for the final event in sub-set "*m*" in 1997
(d)	It is assumed that there will be no savings for the events in excess of $k_m \cdot (i_{94} \cdot G_{97})_m$ which in this case for $k_m = 2$ is twice the number of events represented by $(i_{94} \cdot G_{97})$ in each respective sub-set "*m*".

Figure A-3. General Strategy for Handling Savings for Increased 12-HD use since 1994

New Inference Model. The *New Inference Model* is based on the 26 inference sub-sets with an average savings for each sub-set "m" of $(v_c)_m$, derived from the 1:10 Database (see Table A-8). It is designed to handle both the extensive and the intensive growth of 12-HD usage as described above since the 1:10 Database was developed in 1994.

The mathematical expressions needed for the *New Inference Model* (see Figure A-3) to determine the total net on-farm savings, $(V_c)_m$, for each sub-set *"m"* are as follows:

$$(V_c)_m = (v_c)_m \cdot (n_{97})_m \quad if\ (\frac{i_{97}}{i_{94}})_m \leq 1$$

$$(V_c)_m = (v_c)_m \cdot (i_{94} \cdot G_{97})_m + R_m \cdot (v_c)_m \cdot [n_{97} - (i_{94} \cdot G_{97})]_m \quad if\ 1 < (\frac{i_{97}}{i_{94}})_m < k_m$$

$$(V_c)_m = (v_c)_m \cdot (i_{94} \cdot G_{97})_m + \tfrac{1}{2}\,(v_c)_m \cdot (k_m - 1) \cdot (i_{94} \cdot G_{97})_m \quad if\ (\frac{i_{97}}{i_{94}})_m \geq k_m$$

in which:

$$R_m = \frac{(k_m - 1) \cdot (i_{94} \cdot G_{97})_m - \tfrac{1}{2}[n_{97} - (i_{94}\ G_{97})]_m}{(k_m - 1) \cdot (i_{94} \cdot G_{97})_m}$$

"m" is the subscript representing the sub-set number

$(V_c)_m$ is the total savings for sub-set "*m*" in 1997

$(v_c)_m$ is the average conservation savings per event in sub-set "*m*" from the 1:10 Database

$(n_{94})_m$ is the number of events in sub-set "*m*" in 1994

$(n_{97})_m$ is the number of events in sub-set "*m*" in 1997

$(i_{94})_m$ is the intensity in terms of the average number of events per gate in sub-set "*m*" in 1994[3]

$(i_{97})_m$ is the intensity in terms of the average number of events per gate in sub-set "*m*" in 1997

$(G_{94})_m$ is the number of gates served in sub-set "*m*" in 1994

$(G_{97})_m$ is the number of gates served in sub-set "*m*" in 1997

k_m is the (savings per event) slope adjustment factor for sub-set "*m*"

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3 The intensity is computed by: $(i_{94})_m = (n_{94}/G_{94})_m$

Computing the Total Savings Using the *New Inference Model*

The total conservation savings for 1997 is the sum of the savings for each of the 26 inference sub-sets. However, before the savings for each inference sub-set can be determined, the *k factor* associated with each inference sub-set *"m'* must be established.

Establishing the *k factors*. The general feel for the intensive growth of the types and uses of 12-HDs was gained from the field studies mentioned above (see Table A-7). This general feel was used to arrive at what the CVC believes are reasonable *k factors* for each of the 26 inference sub-groups. The final *k factors* selected are either 1.5 or 2.0, with 2.0 being used for all 5-cfs, drip, sprinkle, and all small-cfs inference sub-sets (see Table A-11). The basis for using the higher value, which has the lesser effect on reducing savings due to intensive growth, for the 5-cfs sub-sets is because the 5-cfs cap effectively forced their growth. The basis for the higher value for drip and sprinkle sub-sets is because more crops are being fully grown under drip and sprinkle irrigation. And the basis for the higher value for the all 0.5-, 1-, 1.5-, and 2-cfs sub-sets is because these sub-sets contain large and increasing numbers of 12-HDs serving drip, sprinkle, and specialized high intensity surface irrigated fields.

Example calculation. Following is a sample calculation for determining the value the net on-farm 12-HD savings (for Inference Sub-set "m" # 24, $(V_c)_{24}$, using the *New Inference Model* with $k = 2$ and data from Tables A-8 and A-10:

1. Compute the value of $(i_{97}/i_{94})_{24}$, which is the EPG Ratio (see Table A-11) by:

   $(i_{94})_{24} = (n_{94}/G_{94})_{24} = 816/205 = 4.0$

   $(i_{97})_{24} = 1906/283 = 6.7$

   Thus: $(i_{97}/i_{94})_{24} = 6.7/4.0 = 1.68$

2. Since $1 < 1.68 < 2$, ie. 1 is less than 1.68 and 1.68 is less than $k = 2$, use the second equation presented for the *New Inference Model* on the previous page to compute $(V_c)_{24}$ by inserting the following values in it:

   $(i_{94})_{24} = 4.0$ events/gate; $(G_{97})_{24} = 283$ gates; $(v_c)_{24} = 0.784$ AF/event; $(n_{97})_{24} = 1906$ events; and also noting that $(i_{94} \;\; G_{97})_{24} = (4.0 \text{ x } 283) = 1{,}132$ events[4] and that:

   $R_{24} = [(2 - 1) \text{ x } 1{,}132 - 0.5 \text{ x } (1{,}906 - 1{,}132)]/[(2 - 1) \text{ x } 1{,}132] = 0.658$[5]

   To obtain:

   $(V_c)_{24} = (0.784 \text{ x } 1{,}132) + [(0.658 \text{ x } 0.784) \text{ x } (1{,}906 - 1{,}132)] = 1{,}287$ AF

---

4 This is the number of events represented by point (a) on Figure A-3

5 This multiplied by $(v_c)_{24} = 0.784$ AF/event is the savings per event value represented by point (b) on Figure A-3

Table A-11. Estimated Net On-Farm 12-HD Savings Using WIS Data for the 1997 Water Year and the Revised EU Values Without and With the New Inference Model.

Without New Model			With New Model			
Inference Sub-Set[1]	Count	Sum Vc (AF)	k Factor	Sum Vc (AF)	Delta	EPG Ratio[2]
1. drip3_7	807	1,816	2.0	1807	9	1.10
2. flat3_4spf	823	1,205	1.5	1173	32	1.18
3. flat3_4wsu	858	1,435	1.5	1419	16	1.11
4. flat5spf	1621	2,869	2.0	2759	110	1.32
5. flat5wsu	827	1,984	2.0	1952	32	1.20
6. flat6_7f	93	232	1.5	222	10	1.23
7. flat6_7sp	113	218	1.5	218	0	0.97
8. flat6_7su	1348	3,458	1.5	3450	8	1.05
9. flat6_7w	361	774	1.5	774	0	0.97
10. row3_4f	693	1,288	1.5	1233	55	1.23
11. row3_4sp	708	1,139	1.5	1129	10	1.10
12. row3_4su	183	331	1.5	265	66	1.56
13. row3_4w	1107	1,828	1.5	1819	9	1.07
14. row5spf	1355	2,777	2.0	2636	141	1.37
15. row5wsu	786	1,977	2.0	1920	57	1.27
16. row6_7f	68	205	1.5	199	6	1.19
17. row6_7sp	70	181	1.5	181	0	0.73
18. row6_7su	309	569	1.5	562	7	1.12
19. row6_7w	278	633	1.5	632	1	0.87
20. sp3_4	2084	4,237	2.0	4179	58	1.18
21. sp5	1329	3,054	2.0	2989	65	1.23
22. sp6_7	320	944	2.0	836	108	1.61
23. all0.5	471	203	2.0	203	0	0.99
24. all1	1905	1,494	2.0	1287	207	1.68
25. all1.5	948	1,201	2.0	1201	0	0.74
26. all2	2452	3,609	2.0	3,582	27	1.13
Subtotal	21,917	39,660		38,627	1,033	
Wt. Avg	---	---		---	---	
Unspecified	37	72		72	0	
Total	21,954	39,732		38,699	1,033	

[1] Examples for interpreting the inference sub-set symbols are:

Row 2: flat3_4spf is flat irrigation with delivery rates between 2.5 and 4.0 cfs in the spring and fall.
Row 15: row5wsu is row irrigation with delivery rates between 4.5 and 5.0 cfs in the winter and summer.
Row 22: sp6_7 is sprinkler irrigation with delivery rates between 5.5 and 7.0 cfs in all seasons.
Row 23: all0.5 is for all methods with delivery rates less than or equal 0.5 in all seasons.

[2] EPG Ratio is the ratio of the number of events per gate in 1997 to the number in 1994.

Total savings. Table A-11 contains the estimated net on-farm 12-HD savings computed for each of the 26 inference sub-sets and the total savings using WIS data for the 1997 CFS year and the revised EU values without and with the *New Inference Model*. The "Without New Model" columns are the same as the first three columns in Table A-9. The Sum V_C column included with the "With New Model" columns contains the savings values computed using the *New Inference Model* with the indicated *k factors*. The Delta column contains the differences between the savings without and with the *New Inference Model* and events per gate, EPG, Ratio column gives the values of $(i_{97}/i_{94})_m$ for each inference sub-set *"m"*. The EPG Ratios provides an indication of the intensity of the growth in usage, the higher the ratio the greater the intensification.

Using the *New Inference Model* with the 26 inference sub-sets gives an estimated total net 12-HD on-farm savings of 38,699 AF using WIS data for the 1997 CFS year. This is quite close to the estimated total net 12-HD on-farm savings of 38,384 AF computed for the 1998 Projected Savings that was based on 1997 WIS data using 22 inference sub-sets in the previous inference model.

Sensitivity analysis. A sensitivity analysis was made to determine the effect of using different *k factors*. The variable *k factors* used in Table A-11 resulted in a total difference (or reduction) of 1,033 AF between the "Without and With New Model" total net on-farm 12-HD savings estimates. If a constant *k factors* of 2.0 have been used for all 26 of the Inference Sub-Sets, the reduction would have been 923 AF; and for constant *k factors* of 1.5 and 1.25 the respective reductions would have been 1,811 and 3,089 AF.

ACCOUNTING FOR EXTRA 12-HDs TO PROJECT 14 AND 18 FIELDS[6]

Farmers operating Drip, Linear Move Sprinkler, and Tailwater Recovery Systems tend to order more 12-HDs than they would otherwise order for an average combination of all types of systems used throughout the IID service area. Some of these high 12-HD usage systems are sponsored by the IID/MWD Conservation Program falling under Projects 14 and 18, which receive credit for their on-farm conservation elements. Therefore, the savings resulting from the additional 12-HDs induced by Projects 14 and 18 should not be included in the pool of 12-HD conservation savings and credited to Project 9, the 12-HD Program[7]. On the other hand, since the potential increase in spillage is captured by the 12-HD Program the potential spillage should not be subtracted from the savings resulting from the use of Drip, Linear Move Sprinkler, or Tailwater Recovery Systems sponsored under Projects 14 and 18.

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6 This is a new addition that was not included in earlier versions of the 12-HD VSR Addendum.

7 This is necessary because it is unreasonable to have the induced or potential spillage from one Project be Conserved (saved) by another Project and count as Savings in the same Conservation Program, this in effect would be double counting.

A query of the IID Delivery Data Base revealed the following for the 1996 and 1997 WaterYears (periods between November 1 and October 31):

Projects & System Types and (Numbers of Delivery Gates)		Average Number of 12-HDs per Gate 1996	1997
P 14/18 Drip Systems	(3)	80	89
P 14 Linear Move Sprinkler Systems	(3)	53	30
P 18 Tailwater Recovery Systems	(59)	4.7	4.4
All Other IID Systems	(5638)	4.0	3.7

From the above data it is clear that 12-HDs are used much more frequently for both Drip and Linear Move Sprinkler Systems than the average usage throughout the IID service area. However, there is only a small increase in 12-HD usage with Tailwater Recovery Systems.

To handle this situation in the future, the CVC will not count any of the 12-HDs that are delivered to Gates serving Projects 14 and 18 fields. Instead it will be assumed that "on average" if Projects 14 and 18 had not been sponsored by the IID/MWD Conservation Program, the affected fields would have irrigation systems that are similar to those serving the remainder of IID's service area. Therefore, their irrigation managers would order 12-HDs accordingly. Thus for the 1996 Water Year, 4.0 additional 12-HDs would have been added back for each of the (3 + 3 + 59 = 65) gates serving Project 14 and 18 fields. This would have been a total of (4.0 x 65) = 260 additional 12-HDs. The Conservation Savings assigned to each of these 260 additional 12-HDs would be the average savings per 12-HD for the entire IID service area.

If the above strategy had been used for the 1996 Water Year, the net effect would have been to decrease the total number of 12-HDs by:

$$3 \times (80 - 4) + 3 \times (53 - 4) + 59 \times (4.7 - 4) = 416 \text{ deliveries}$$

Based on the average savings of 1.950 AF per 12-HD during the 1996 Water Year, this would have reduced the 1997 Conservation Projection by about 810 AF. If it had been used for the 1997 Water Year, the total number of 12-HDs would have been decreased by:

$$3 \times (89 - 3.7) + 3 \times (30 - 3.7) + 59 \times (4.4 - 3.7) = 376 \text{ deliveries}$$

Based on the average savings of 1.749 AF per 12-HD during the 1997 Water Year, this would have reduced the 1998 Conservation Projection by about 660 AF.

UPDATE OF INDEPENDENT VALIDATION ANALYSIS

The Initial VSR provides independent backup for the conservation estimate derived from the individual irrigation event based strategy that utilized the 1:10 Database of grower/irrigator's responses to the 1:10 12-HD queries conducted during the 1994 Water Year. For the individual event based strategy, which is depicted in the upper part of Figure 1 (in the Initial VSR), the "inflow" differentials (for each 12-HD as compared to the 24-HD it replaced) is estimated for each irrigation of any "field" receiving a 12-HD. Thus it is a "single event" based strategy and the total conservation savings is the sum of the estimated conservation savings from each of the 12-HD events.

Two conservation savings estimating strategies were employed for the validation analysis, an analysis of *finish heads* and an analysis of *delivery differentials*. These validation techniques were based on "multiple event" strategies using "district-wide" differential "inflow" information and is depicted in the lower portion of Figure 1. The order and delivery information stored in IID's WIS files was used for the validation analysis. The primary data source for this analysis was the most recent version of the "CFS Files" created through a query of IID's WIS files computer. These records include district-wide irrigation events for the CFS Years from July 1, 1986 through June 30, 1998.

Finish Head (FH) Analysis

An analysis of the CFS Files was made to separate the deliveries into six categories by annual delivery days and AF delivered for each of the past nine 12-month periods (beginning with July 1, 1986 through June 30, 1998, see Table A-10). The purpose of the FH analysis was to determine how the use of FHs has been affected by the 12-HD Program. The latest tallies in Table A-12 (from 1996 to 1998) indicate that about 20 percent of all 12-HDs are FHs. These have replaced almost half of the 24-HD FHs. Furthermore, the average FH delivery has decreased by approximately 1.0 AF/day (11.2 AF/day for 1987 through 1989 less 10.2 AF/day for 1990 through 1998) even though the average 24-HD has increased over the last nine years (see Table A-12).

Assuming that the characteristics of the remaining 24-HD FHs have not changed, the difference in the average quantity of water, 1.0 AF/day, delivered per FH event before and after the 12-HD Program began can be used to estimate the average savings associated with each 12-HD FH event. To do this the 1.0 AF/day is multiplied by 9,585 days (the average number of FH delivery days per year during the nine post-project years) to obtain an average FH delivery difference of 9,585 AF between the pre- and post-12-HD Program periods. This delivery difference of 9,585 AF is then divided by 3,749, the average number of 12-HD FH delivery days during the post-project period to obtain an average gross on-farm savings for each 12-HD FH. Given the average effective utilization, EU = 0 % (to drain) for the "FH" responses in the 1:10 Database, the average net on-farm savings per 12-HD FH is 2.56 AF.

This is well above the average net on-farm savings of 2.06 AF for all surface irrigation events in the 1:10 Grower Database (see Table 5). Furthermore, 12-HD FH irrigations represent almost half (43 percent) of all 12-HD surface irrigation events. **Thus the updated finish head analysis provides strong analytical and independent non-subjective support to the validity of the estimated on-farm conservation savings derived from the 1:10 Grower Database.**

Table A-12

Profile of 12- and 24-HD Finish Heads and Non-Finish Head Events*

CFS Year (July 1 -June 30)	Finish Heads			Not Finish Heads			All 12- and 24-Hour Events*		
	24-HD	12-HD	Subtotal	24-HD	12-HD	Subtotal	24-HD	12-HD	Total
Number of Delivery Days									
1987	8,061	0	8,061	147,217	183	147,400	155,278	183	155,461
1988	7,850	0	7,850	146,303	1	146,304	154,153	1	154,154
1989	9,306	0	9,306	168,083	0	168,083	177,389	0	177,389
1990	8,741	394	9,135	169,116	5,347	174,463	177,857	5,741	183,598
1991	6,006	2,441	8,447	152,850	12,318	165,168	158,856	14,759	173,615
1992	5,012	3,428	8,440	141,843	12,214	154,057	146,855	15,642	162,497
1993	4,552	3,615	8,167	134,461	12,786	147,247	139,013	16,401	155,414
1994	5,051	4,180	9,231	153,044	15,898	168,942	158,095	20,078	178,173
1995	5,125	4,496	9,621	151,056	17,647	168,703	156,181	22,143	178,324
1996	5,851	5,304	11,155	152,239	19,339	171,578	158,090	24,643	182,733
1997	6,280	5,201	11,481	154,803	19,115	173,918	161,083	24,316	185,399
1998	5,899	4,686	10,585	157,105	19,299	176,404	163,004	23,985	186,989
Average 1987-89	8,406	0	8,406	153,868		153,929	162,273		162,335
Average 1990-95	5,748	3,092	8,840	150,395	12,702	163,097	156,143	15,794	171,937
Average 1996-98	6,010	5,064	11,074	154,716	19,251	173,967	160,726	24,315	185,040
Average 1990-98	5,835	3,749	9,585	151,835	14,885	166,720	157,670	18,634	176,305
Average Irrigation Delivery (AF/Day)									
	Average	Average	Weighted Average	Average	Average	Weighted Average	Average	Average	Weighted Average
1987	11.12	N/A	11.12	14.93	4.94	14.92	14.73	4.94	14.72
1988	11.44	N/A	11.44	14.90	9.92	14.90	14.72	9.92	14.72
1989	11.16	N/A	11.16	14.89	N/A	14.89	14.70	N/A	14.70
1990	11.43	4.23	11.11	14.94	3.46	14.59	14.77	3.51	14.42
1991	12.66	6.15	10.78	15.35	4.14	14.51	15.24	4.47	14.33
1992	13.76	5.88	10.56	15.66	4.05	14.74	15.60	4.45	14.53
1993	14.34	5.27	10.32	15.54	3.86	14.52	15.50	4.17	14.30
1994	14.28	5.28	10.20	15.79	3.76	14.66	15.74	4.08	14.43
1995	14.36	5.51	10.22	16.19	3.86	14.90	16.13	4.20	14.65
1996	13.76	5.51	9.84	16.90	3.83	15.43	16.78	4.19	15.09
1997	13.14	4.73	9.33	16.52	3.46	15.09	16.39	3.73	14.73
1998	13.14	4.80	9.45	15.68	3.39	14.33	15.59	3.67	14.06
Average 1987-89	11.24		11.24						
Average 1990-95	13.47	5.39	10.53						
Average 1996-98	13.35	5.01	9.54						
Average 1990-98	13.43	5.26	10.20						

* Stock orders are not included.

Delivery Differential Analysis

An analysis of the CFS Files was made to separate the deliveries into three categories by annual delivery days and AF delivered for each of the past nine 12-month periods (beginning with July 1, 1986 through June 30, 1998). The three categories are: 24-HDs; 12-HDs; and combined 24-HDs and 12-HDs. The results of this query of the CFS Files are presented in Table A-13.

The total volume of order days (ODs) has not changed very much during the study period (see Table A-13). However, the average delivery per OD has decreased by approximately 0.32 AF/day (14.712 AF/delivery-day for 1987 through 1989 less 14.394 AF/delivery-day for 1997 and 1998[8]) even though the average 24-HD has increased over the last nine years (see Table A-11). This is practically the same as the difference obtained in the Delivery Differential Analysis in the Initial VSR for Part I[9].

The average 12-HD would need to be 6.2 AF/day for the post-12-HD project average delivery per OD to be the same as for the pre-project period. This is close to twice the average 12-HD, which is an indication that farmers are not generally abusing 12-HDs by simply replacing their small 24-HDs with 12-HDs having twice the flow rate and only using them for half as long.

Assuming that the characteristics of the remaining 24-HDs have not changed appreciably, the difference in the average quantity of water, 0.32 AF/day, delivered per OD before the 12-HD Program began and during 1997 and 1998 can be used to estimate the average annual savings associated with the 12-HD Program (or the average savings per 12-HD). To do this the 0.32 AF/day is multiplied by 186,194 delivery-days (the average number of ODs per year during 1997 and 1998) to obtain an average delivery difference of approximately 59,600 AF between these pre- and post-12-HD Program periods. This delivery difference of 59,600 AF can be divided by 24,151 (the average number of 12-HDs during the 1997 and 1998 period) to obtain an average gross on-farm savings of approximately 2.47 AF for each 12-HD.

The revised volume weighted average (or global) effective utilization, EU = 16 % for the 1:10 Grower Database (see Table A- 2). Thus the average annual net on-farm savings per 12-HD based on the above analysis would be: (1 - 0.16) x 2.47 = 2.08 AF. This is considerably higher than the average net on-farm savings of 1.76 AF/12-HD estimated for the 1997 data based on the latest inference model and including all interceptor projects (see Table A-13). However, it includes the reduced farm deliveries associated with Tailwater Recovery Systems (TRS) and the additional flexibility provided for 24-hour deliveries (AdFx) since the 12-HD Program began.

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8 The data for 1996 was not used in the analysis due to the unusually high average 24-HD deliveries, which may have been the result of the consolidation of the IID Divisions and the initiation of the 5 cfs caps on the 12-HD Program.

9 There are some discrepancies between the data presented in Table 9 in the Initial VSR and Table A-13 for 1991, 1994, and 1995, especially for 1995. The CVC can not explain these discrepancies. Assuming the data presented in Table A-13 is the most accurate, the average delivery per OD should have been 0.27 AF/delivery-day rather than 0.32 AF/delivery-day presented and used in the earlier analysis.

Table A-13
12-HD Conservation Savings Based on Delivery Sizes and Numbers

CFS Year (July 1 -June 30)	24-HD Deliveries			12-HD Deliveries			Combined 24-HD and 12-HD Deliveries		
	Ave Delivery (AF/day)	Number of Order Days	Total (AF)	Ave Delivery* (AF/day)	Number of Order Days	Total (AF)	Ave Delivery (AF/day)	Number of Order Days	Total (AF)
1987	14.731	155,278	2,287,400	4.941	183	904	14.719	155,461	2,288,230
1988	14.721	154,153	2,269,286	9.918	1	10	14.721	154,154	2,269,301
1989	14.698	177,389	2,607,264	N/A	0	0	14.698	177,389	2,607,264
1990	14.770	177,857	2,626,948	3.509	5,741	20,145	14.418	183,598	2,647,116
1991	15.244	158,856	2,421,601	4.472	14,759	66,002	14.328	173,615	2,487,556
1992	15.599	146,855	2,290,791	4.450	15,642	69,607	14.526	162,497	2,360,431
1993	15.500	139,013	2,154,702	4.172	16,401	68,425	14.304	155,414	2,223,042
1994	15.739	158,095	2,488,257	4.080	20,078	81,918	14.425	178,173	2,570,146
1995	16.127	156,181	2,518,731	4.195	22,143	92,890	14.645	178,324	2,611,555
1996[a]	16.784	158,090	2,653,383	4.188	24,643	103,205	15.085	182,733	2,756,527
1997	16.391	161,083	2,640,311	3.733	24,316	90,772	14.731	185,399	2,731,113
1998	15.585	163,004	2,540,417	3.667	23,985	87,953	14.056	186,989	2,628,317
Average of 1987 - 1989	14.717	162,273	2,387,983				14.712	162,335	2,388,265
Average of 1990 - 1995	15.497	156,143	2,416,838	4.146	15,794	66,498	14.441	171,937	2,483,308
Average of 1997 - 1998	15.988	162,044	2,590,364	3.700	24,151	89,362	14.394	186,194	2,679,715
Ave 1990-95, 1997-98	15.619	157,618	2,460,220	4.035	17,883	72,214	14.429	175,501	2,532,409
Difference ('Ave 1987 - 1989' - 'Ave 1990-95, 1997-98')							0.283		
* The average 12-HD would have to be 6.808 AF for no change in the overall average delivery size. (Difference ('Ave 1987 - 1989' - 'Ave 1990-95, 1997-98'))									
Target	15.619	157,618	2,460,220	6.808	17,883	121,750	14.712	175,501	2,581,970
Difference ('Ave 1987 - 1989' - 'Ave 1997 - 1998')							0.318		
* The average 12-HD would have to be 6.166 AF for no change in the overall average delivery size. (Difference ('Ave 1987 - 1989' - 'Ave 1997 - 1998'))									
Target	15.988	162,044	2,590,364	6.166	24,151	148,919	14.712	186,194	2,739,283

[a]Eliminated from analysis due to unusually high average 24HD delivery size. Consolidation of divisions may have affected this.

Based on a comparison of the pre-project period and 1998, the average delivery per OD has decreased by approximately 0.66 AF/delivery-day (14.712 AF/delivery--day for 1987 through 1989 less 14.056 AF/delivery-day for 1998). The average 12-HD would need to be 8.8 AF/day for the post-12-HD project average delivery per OD to be the same as for the pre-project period. This gave an average delivery difference of approximately 129,200 AF between these pre- and 1998 12-HD Program periods. Assuming 4,700 AF is TRS water and 40 percent of the remaining difference is due to AdFx savings, the difference attributed to the 12-HDs would be roughly 75,000 AF. Dividing this difference by 23,985 (the average number of 12-HDs during the 1998 period) and adjusting for EU=16% gives an average gross on-farm savings of approximately 2.63 AF for each 12-HD. This is considerably higher[10] than the average net on-farm savings of 1.76 AF/12-HD estimated for the 1997 data based on the latest inference model.

In view of the above considerations the update of the delivery-day analysis provides strong analytical and independent non-subjective support indicating that the estimated on-farm conservation savings derived from the 1:10 Grower Database may be on the low or conservative side.

LAYPERSON'S GUIDE TO THE 12-HD PROGRAM

The attached Layperson's Guide to the 12-HD Program was developed by the Water Conservation Measurement Committee, Conservation Verification Consultants, and the Imperial Irrigation District staff. It was designed to document and describe the Program and provide examples of actual on-farm delivery reductions resulting from the use of 12-HDs.

Before the Layperson's Guide was distributed, IID's Water Conservation Advisory Board requested that the CVC present their verification strategy and findings related to the 12-HD Program at a special meeting sponsored by the IID/MWD Water Conservation Agreement. This meeting, which was advertised throughout the District, was held on June 19, 1997 in IID's Water Control Center.

The special meeting was well attended and provided a forum for questions to be posed and answered. The Water Conservation Advisory Board was informed by the Water Conservation Measurement Committee Chairman that if additional meetings were desirable for further discussion of the 12-HD Program such meetings would be scheduled.

Subsequent to the special meeting the CVC prepared a special report that contained the exhibits used at the meeting. This report contains a summary of the historical use of 12-HDs and the CVC's verification strategy and findings. The title of this special report is:

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10 Part of this may be due to an increase in the number of small 24-HDs that serve the expanded acreage irrigated with drip and solid set sprinkle systems. This would reduce the average 24-HD even if the 12-HD Program were not in place and be partly responsible for the overall decrease in the average AF/delivery-day.

VERIFICATION OF THE 12-HOUR RUN PROGRAM
A Report on the
Special Meeting of the Water Conservation Advisory Board
Presented by
Conservation Verification Consultants
on
June 19, 1997

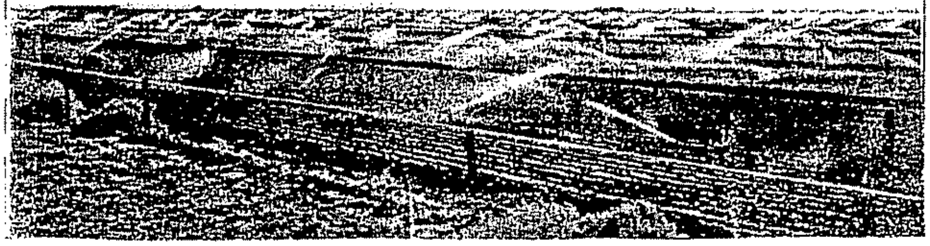
On June 21, 1997 the CVC presented a seminar for the Water Conservation Measurement Committee and selected IID Staff. The seminar covered the strategies used in developing the savings associated with the 12-HD Program The following special report was prepared to document this materials used during this presentation:

PROJECT 9
12-HOUR DELIVERY PROGRAM
ON-FARM WATER SAVINGS
VERIFICATION PROCEDURES
Seminar
June 1997

Subsequent to these special meetings, it was decided that it would not be necessary or particularly desirable to distribute the Layperson's Guide; therefore, it has never been widely distributed and is included herein for future reference.

Revised: 12/31/96

Imperial Irrigation District
A Layperson's Guide
12-Hour Delivery Program

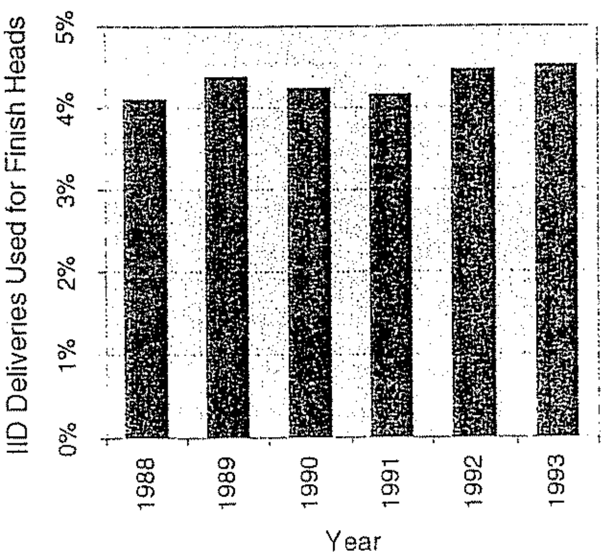


Why 12-Hour Deliveries Are Needed

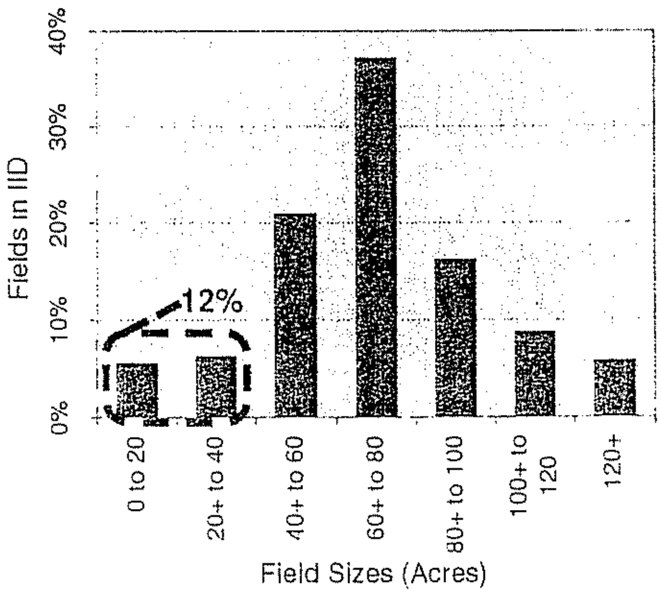
Flexible water delivery is needed for efficient on-farm irrigation. IID has historically provided growers with flexibility in delivery ***frequency*** and ***rate*** by providing water within a day of being ordered and allowing growers to order almost any flow rate. However, until it adopted the 12-Hour Delivery Program, the IID requirement that water be taken in increments of 24-hours limited flexibility in ***duration*** and did not always allow growers to make the most efficient use of delivered water.

For example, the minimum flows needed to push water to the ends of small fields may provide more water than needed if delivered for 24 hours. Similarly, finish heads, which are used to complete irrigation on small portions of larger fields, typically are not needed for 24 hours. Germination and cooling irrigations of Fall vegetables with sprinklers are generally needed for only a few hours. Likewise, drip irrigation systems, which are gaining popularity in IID, typically need to operate every day or two for only a few hours. When growers have no option but to take water for a full 24 hours, any excess water must be reused on nearby fields with only partial effectiveness or spilled to drains.

The 12-Hour Delivery Program, part of a broad water conservation program implemented under the IID / Metropolitan Water District of Southern California (MWD) Water Conservation Agreement, which became effective in December 1989, was designed to provide more flexibility in irrigation duration. It allows farmers to terminate delivery and leave any unused water in the IID system after 12 hours, or at any time upon 3 hours notification to IID. The unused water can then be delivered to another user or routed to one of IID's several regulating reservoirs for subsequent delivery to another user.



There are approximately 170,000 deliveries each year in IID. About 4% of these are finish heads.

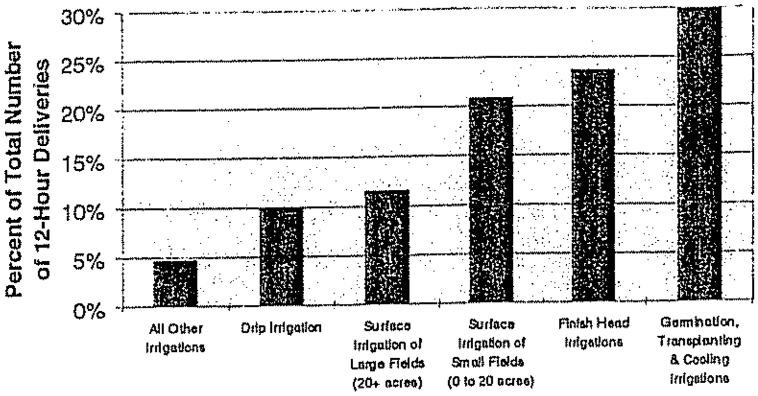


12 % of the fields in IID are smaller than 40 acres.

Uses of 12-Hour Deliveries

About 3/4 of all 12-hour deliveries are used for either cooling, germination, transplanting, finish heads, or irrigating small fields. Most of these irrigations take place on vegetable and melon fields.

Of the remaining 1/4, most are used for surface irrigation on large fields and drip irrigation, evidence that most 12-hour deliveries are used as originally intended. However, a small number of 12-hour deliveries are used primarily for grower convenience or to reduce irrigation labor costs (see box this page).



Most 12-hour deliveries are used for special events (like finish heads) and small surface-irrigated fields.

Water is Saved by Reducing On-Farm Deliveries

12-hour deliveries save water by allowing growers to order the flow they need for efficient irrigation and terminate their delivery early, thereby holding unused water in IID's canal system for use elsewhere.

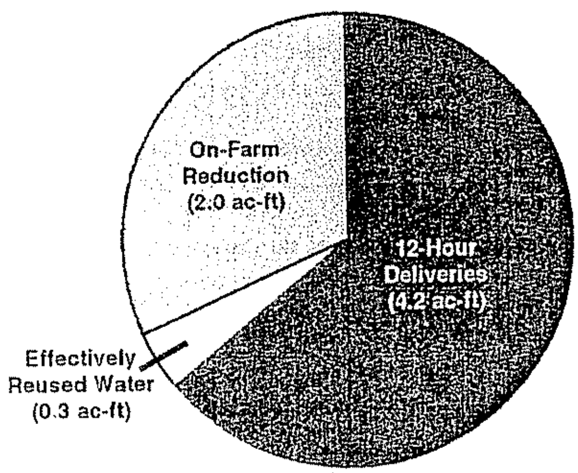
The amount of water saved has been determined from data collected from more than 1,600 randomly selected 12-hour irrigations. For each event, growers were asked to estimate how much water they would have ordered for a 24-hour delivery (if 12-hour deliveries had not been available) and whether any excess water would have been effectively reused. The responses to these questions plus followup personal interviews to verify responses provide the basis for computing the water savings of each 12-hour irrigation studied.

IID's long-term water delivery records have also been analyzed to provide independent checks of the on-farm water savings estimates. These analyses, based on a comparison of water delivery records before and after the start of the 12 Hour Delivery Program, confirm the estimates based on farmers' responses.

On average, each 12-hour irrigation had a volume of 4.2 acre-feet compared to a volume of 6.5 acre-feet for the 24-hour irrigation that would have been used. However, a small portion (0.3 acre-feet) of the 24-hour volume would have been effectively reused on nearby fields, resulting in a net on-farm delivery reduction of 2.0 acre-feet.

The average 12-hour event results in a net on-farm delivery reduction of 2.0 acre-feet, based on how much water was actually delivered, how much would have been delivered, and the portion of the excess that would have been effectively reused.

Average 24-Hour Delivery (6.5 acre-feet)



Saving Water or Labor?

There are many benefits of the 12-Hour Delivery Program, including water savings, better irrigation performance, and reduced flows to the Salton Sea. In addition, some growers report that 12-hour deliveries can be used to reduce irrigation labor costs.

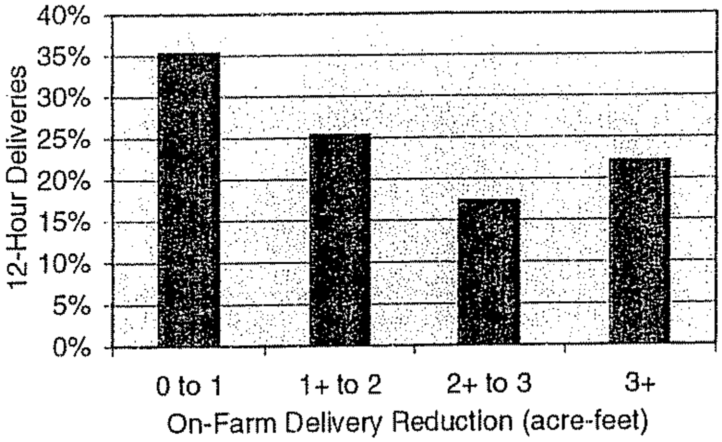
Studies were conducted to determine if this program is actually saving water or merely providing grower convenience. These studies revealed that there are situations where 12-hour deliveries are used primarily for convenience and labor savings, but there are relatively few of these situations which have little effect on overall water conservation.

IID restricts the maximum 12-hour delivery flow rate to assure that the flexibility is used primarily for water savings. The limit has been 7 cfs and IID is currently evaluating a reduction to 5 cfs during periods of heavy 12-hour delivery usage. This reduction is designed to minimize the opportunity for growers to use 12 hour deliveries primarily for labor savings and to keep main canal flow fluctuations within safe and manageable limits.

The delivery reduction resulting from each 12-hour event varies according to what the grower would have done in the absence of the program, how long the 12-hour delivery actually lasted, the 12-hour flow, and other factors.

The graph at the right shows that about 60% of all 12-hour events reduce on-farm delivery by 2 acre-feet or less and 40% by more than 2 acre-feet with the overall average saving of 2.0 acre-feet.

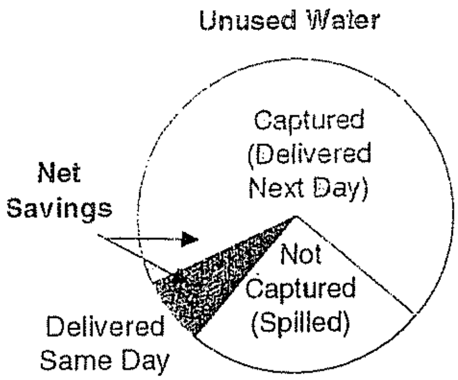
The table below shows data compiled for four actual 12-hour deliveries.



Examples of Actual On-Farm Delivery Reductions

	Example 1	Example 2	Example 3	Example 4
Crop	Lettuce	Sudan Grass	Watermelons	Alfalfa
Irrigation Method	Sprinkler	Flat	Drip	Flat
Field Size/Area Irrigated with this 12-Hour Delivery	35 acres / 35 acres	221 acres / 20 acres	70 acres / 70 acres	243 acres / 15 acres
Month Irrigated	September	October	April	July
Irrigation Purpose	Germination	Finish Head	Regular	Finish Head
Actual 12-Hour Order	2.5 cfs	7 cfs	2.5 cfs	6 cfs
Would Have Ordered (for 24 hours)	1.5 cfs	4 cfs	2.5 cfs	6 cfs
Actual 12-Hour Delivery Duration	11 hours	12 hours	10 hours	12 hours
Would Have Delivered (for 24 hours)	3.0 acre-feet	8.0 acre-feet	5.0 acre-feet	12.0 acre-feet
Reused (24-Hour) Water	0.0 acre-feet	0.0 acre-feet	0.2 acre-feet	0.6 acre-feet
Actual 12-Hour Delivery	2.3 acre-feet	7.0 acre-feet	2.1 acre-feet	6.0 acre-feet
On-Farm Reduction	0.7 acre-feet	1.0 acre-feet	2.7 acre-feet	5.4 acre-feet
Explanation: These 12-hour deliveries are a sampling of more than 1,600 events that were studied in detail.	This vegetable field was germinated with sprinklers, which often require an extra one-half cfs buffer to avoid a shortage at the pump intake. The savings of this event is due mainly to the size of the apparent buffer and the irrigation duration	This finish head added about 7 acre-feet of water to finish irrigating the last 20 acres of a 221-acre field. Most flat-irrigated fields are difficult to irrigate with less than about 4 cfs, so the minimum 24-hour irrigation would have added 8 acre-feet	This drip system cannot operate effectively at a lower flow, so there would have been excess water with a 24-hour delivery. A small amount of that excess would have been reused, so the delivery was reduced significantly	This grower ordered 6 cfs for 12 hours to water the last 15 acres of a 243-acre field. Without the 12-Hour Delivery Program, he would have ordered the same flow rate for 24 hours and effectively reused a small amount of the excess water

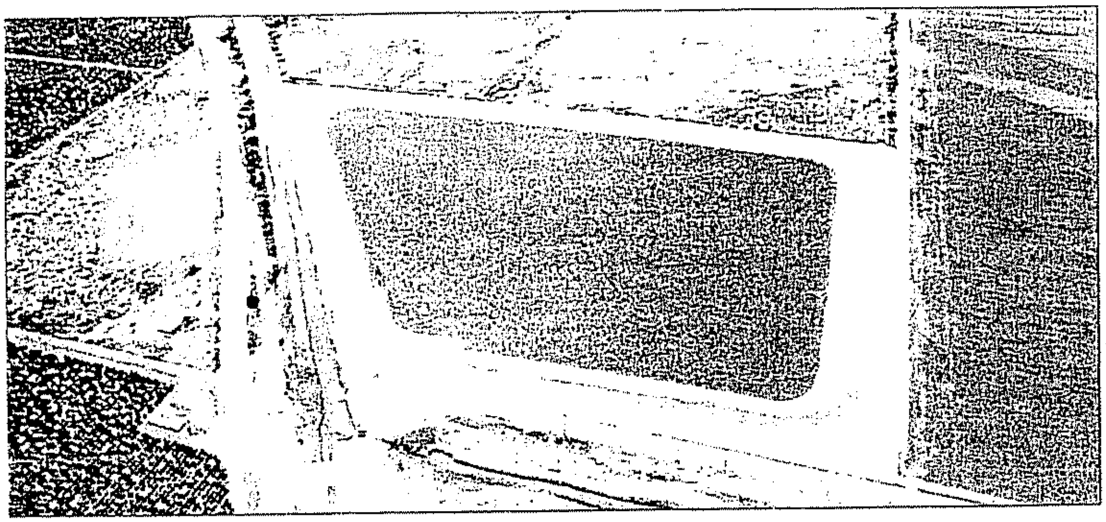
Managing the Unused Water to Maximize Savings



12-hour runs reduce on-farm deliveries and increase spill. Net conservation only includes captured and delivered water.

The water that growers do not use (because of on-farm delivery reductions) remains in the IID distribution system. This water must be captured and stored for later use or it will be spilled and lost. The capture and storage of water are accomplished by IID's canal system automation, regulating reservoirs, and the functioning of the state-of-the-art Water Control Center. These areas were improved or expanded under the IID/MWD Program at a cost of more than $15 million. Studies based on actual field data and records show that most unused water is effectively captured and re-delivered, resulting in a net positive savings due to the 12-hour Delivery Program.

However, studies have also shown that even with these measures there is additional lateral canal spillage that occurs as a consequence of managing the unused water. This spillage occurs when 12-hour deliveries are terminated and the unused water is returned to the laterals. These water operations, which require precise timing, cannot always be done perfectly, even with increased staffing levels funded by the IID/MWD Program.



Reservoirs capture unused water for delivery the following day.

Increased water level fluctuations in the main canal system also tend to cause unsteadiness in lateral flows which contributes to lateral spillage.

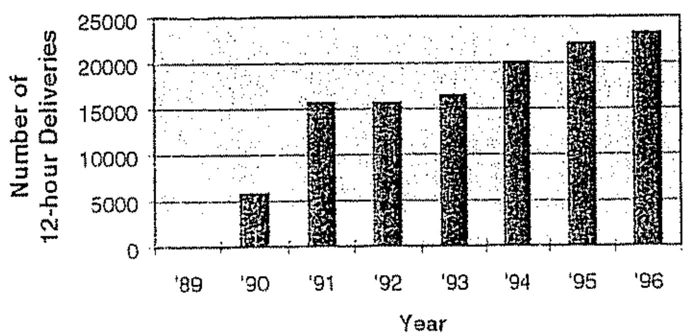
A long-term spillage monitoring program is being implemented to identify possible changes in canal spill patterns.

Will 12-Hour Deliveries Continue to Conserve?

The use of 12-hour deliveries has increased every year since the program was fully implemented in 1989 after a 1988-89 pilot project. More and more growers are using the program and finding new ways to benefit from the program's flexibility.

As the nature and number of 12-hour orders changes, IID will continue data collection as part of an ongoing quality control program. These measures will ensure that 12-hour deliveries are being used as intended:

TO SAVE WATER.



12-hour delivery use has been steadily increasing since the program began.